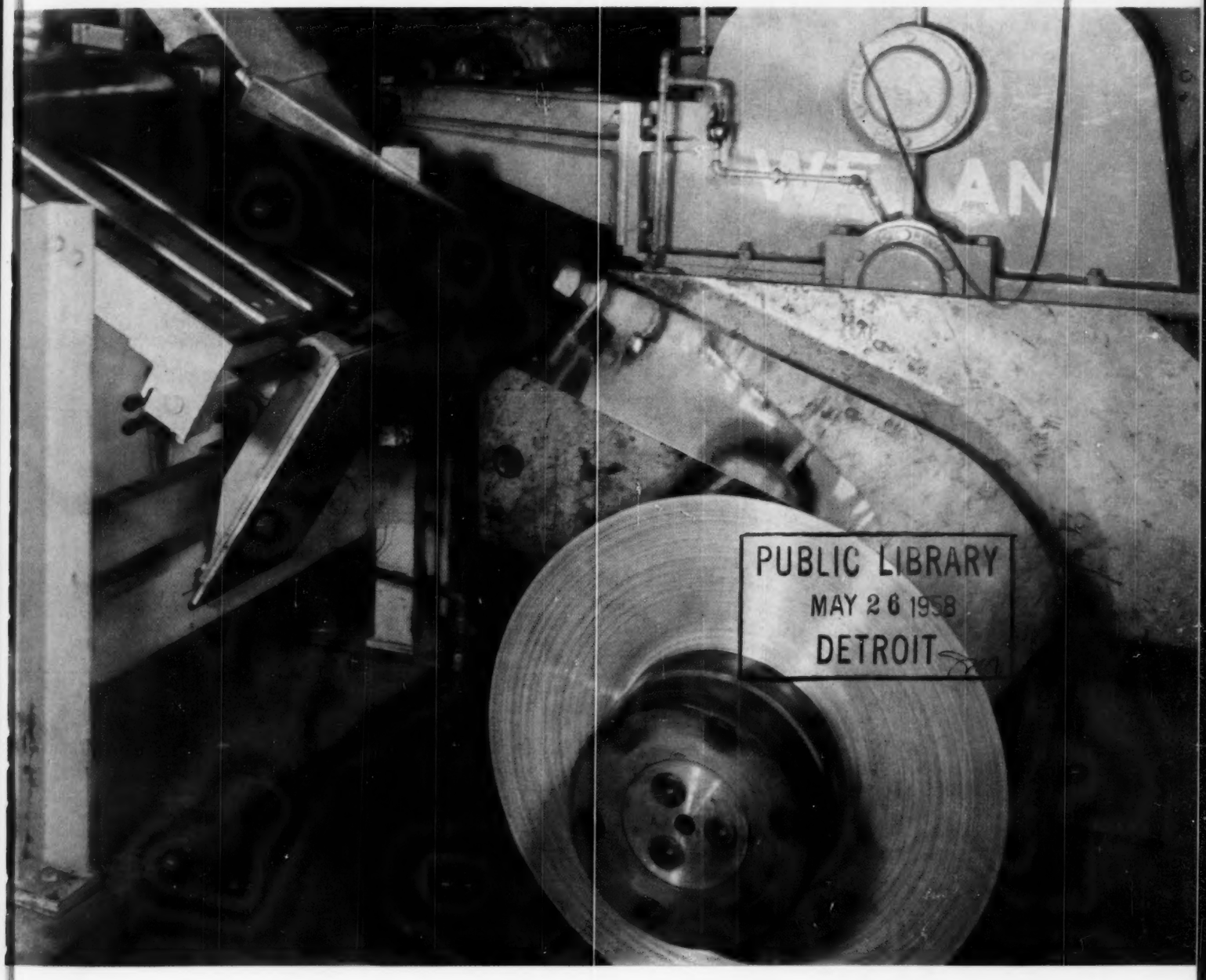
Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

MAY, 1958

TECHNOLOGY DEPT.



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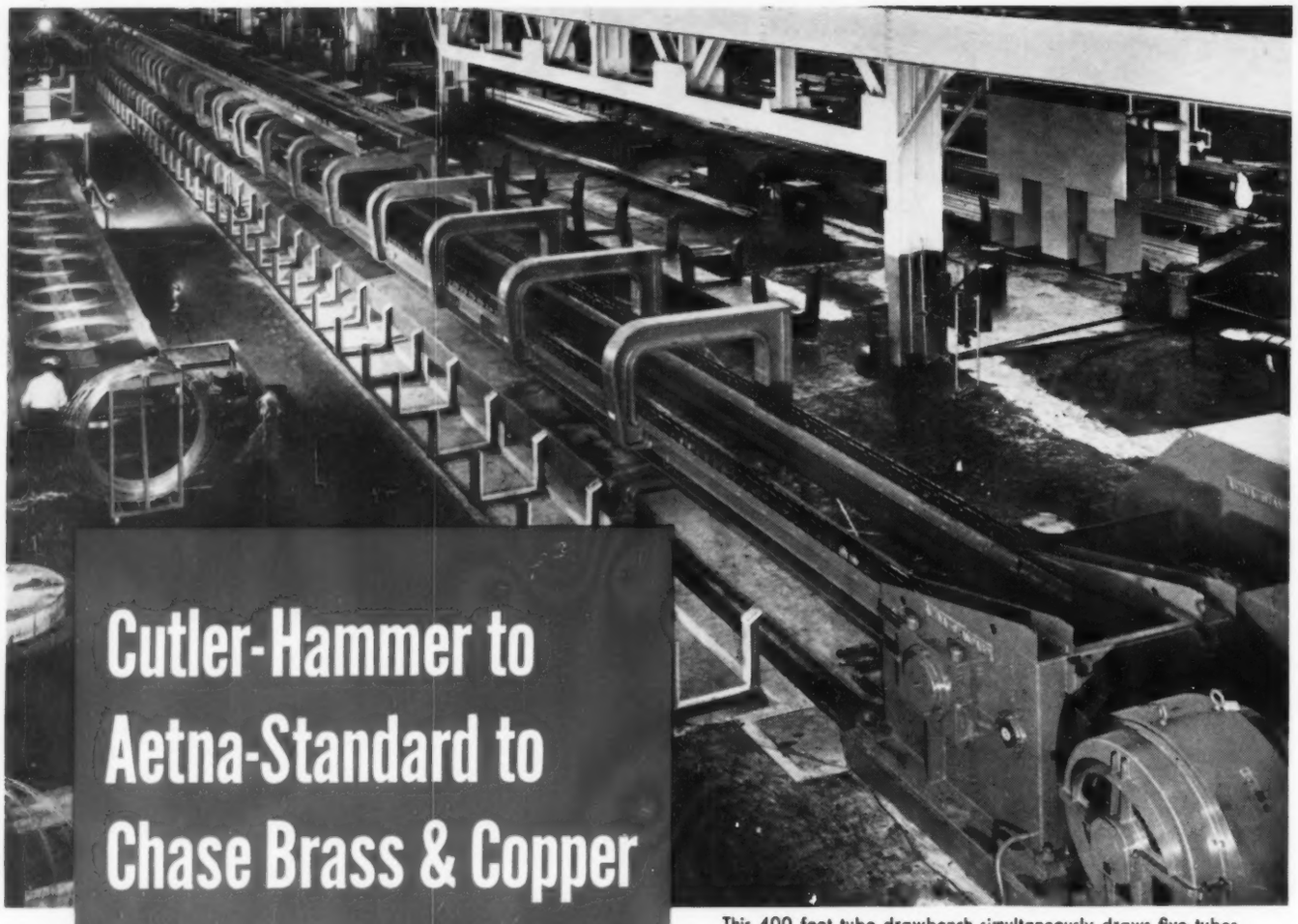
DETROIT

Wean and the Tinplate Industry

Of the 5,000,000 tons of tinplate produced for the container industry in 1956, more than 75% was produced on 47 modern, high speed, Electrolytic Tinning Lines engineered and constructed by Wean.

THE WEAN ENGINEERING COMPANY INC. • WARREN • OHIO



Cutler-Hammer to Aetna-Standard to Chase Brass & Copper

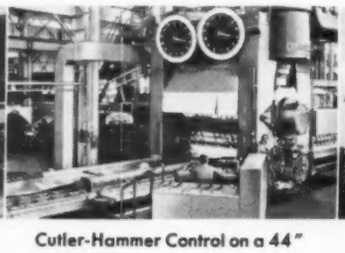
This 400 foot tube drawbench simultaneously draws five tubes to a maximum length of 210 feet. Cutler-Hammer Control varies the drawing speed between 110 and 330 feet per minute.

It takes teamwork to win, and it takes teamwork to develop new and better machines for industry. This mammoth 400 foot Tube Drawbench was constructed by the Aetna-Standard Engineering Company, equipped with Cutler-Hammer Motor Control and installed at the Cleveland Mill of the Chase Brass & Copper Company. Engineers from all three companies worked together to produce this amazing machine, the longest drawbench in the copper and brass industries. Here again is another example where Cutler-Hammer Control was specified because of its reputation for dependability and the design leadership Cutler-Hammer has displayed during the past 65 years. You, too, will find it pays to insist upon Cutler-Hammer for the practical solution to all your control problems involving mill machines and processes.

CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.

CUTLER-HAMMER
MOTOR CONTROL
C-H

Cutler-Hammer Control on a rebuilt sheet temper pass mill.



Cutler-Hammer Control on a 44" taper mill.

Cutler-Hammer Control on a giant ore bridge.

Cutler-Hammer Control on a 10 ton soaking pit crane.

LOOK TO CUTLER-HAMMER MILL EXPERIENCE . . . AS BROAD AS IT IS LONG

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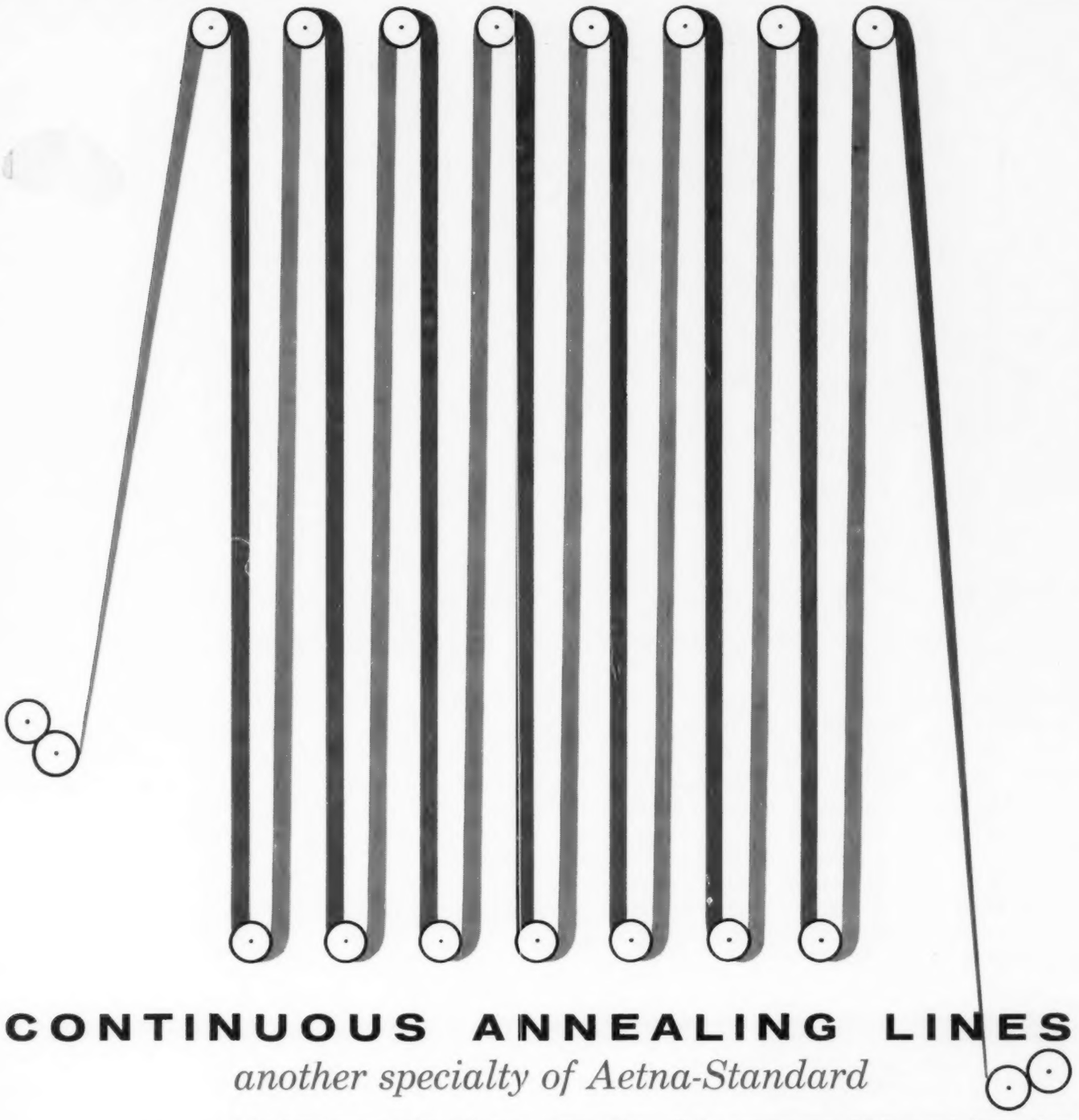

CONTINUOUS ANNEALING LINES

another specialty of Aetna-Standard

Like Continuous Galvanizing or Tinning, a Continuous Annealing Line requires good designing and rugged equipment.

Aetna has much experience in continuous processing lines, galvanizing, tinning and annealing. In fact, Aetna pioneered in continuous equipment. Two of the most recent high speed Aetna lines incorporate many new ideas and innovations, permitting sure tracking at high speeds of 1,000 feet and more.

What can Continuous Annealing do for your production and your costs? Aetna's sales engineers can produce some interesting figures.

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GENERAL OFFICES: PITTSBURGH, PA. • PLANTS: ELLWOOD CITY, PA., WARREN, OHIO • RESEARCH LABORATORY: AKRON, OHIO

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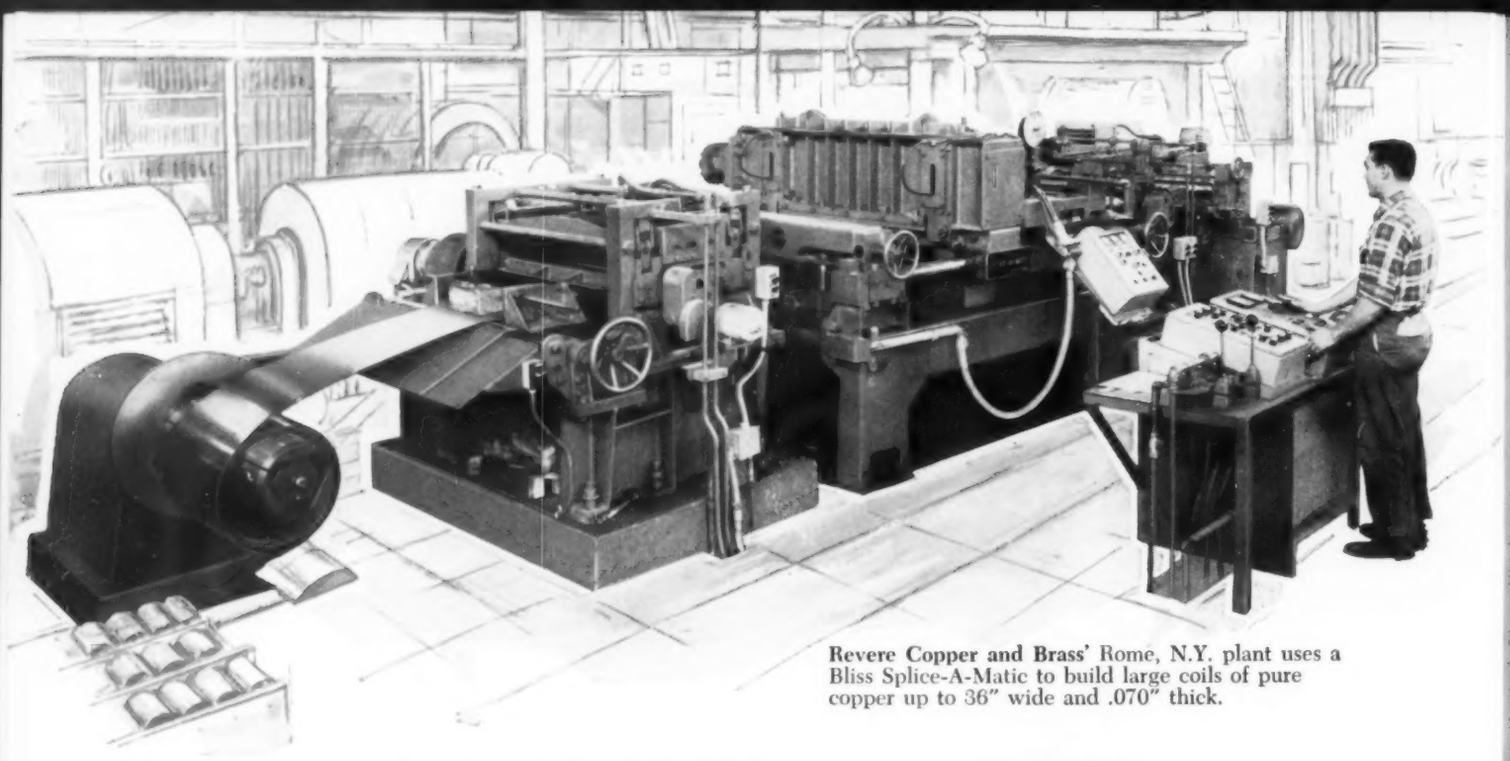

Revere Copper and Brass' Rome, N.Y. plant uses a Bliss Splice-A-Matic to build large coils of pure copper up to 36" wide and .070" thick.

How much could these machines reduce your coil handling costs?

Substantially, if your requirements are at all similar to those of Universal-Cyclops Steel Corporation or Revere Copper and Brass. Universal-Cyclops uses a Bliss Splice-A-Matic welder to cut handling costs in welding carbon and stainless steels, getting ideal welds in even the 300 series.

Revere Copper and Brass uses *its* Splice-A-Matic to build up the larger coils preferred by many of its customers . . . now also finds that these larger coils cut down-time and set-up time in its own subsequent operations.

Just about any weldable material and coil size is practical with the Bliss Splice-A-Matic. It's been used on most alloys in widths to 60" and with both coils and cut-to-length sheets. And complementing the Splice-A-Matic, Bliss offers a complete line of annealers, trimmers, pinch roll stands, levelers, reels, and other units to form a complete, modern coil build-up line.

To learn how others are automating their coil handling and cutting costs write today for complete information.

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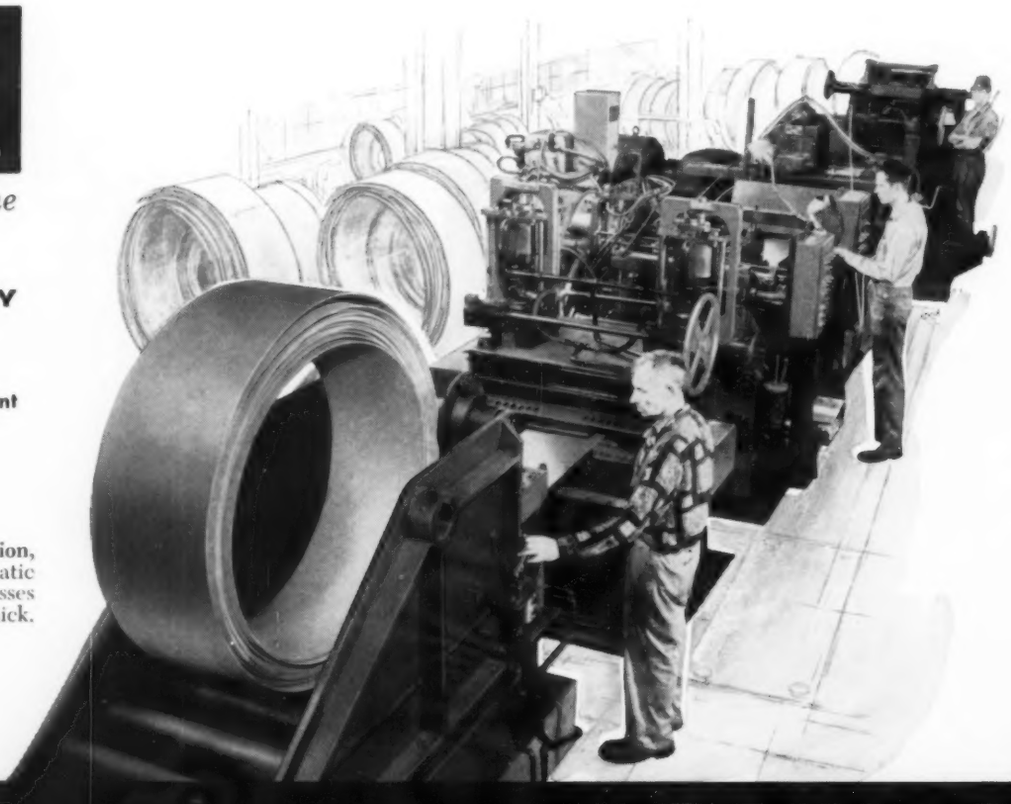

At Universal-Cyclops Steel Corporation, Bridgeville, Pa., a Splice-A-Matic successfully welds 300 Series stainlesses 18½" wide and 0.135" to 0.195" thick.

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Iron AND Steel ENGINEER

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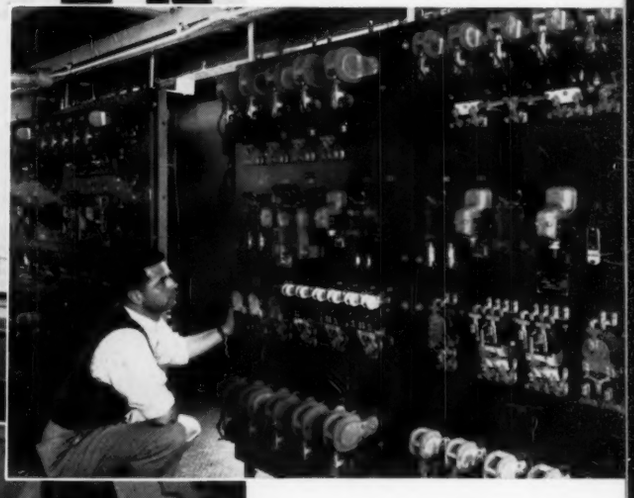
Clark-controlled gantry unloader, capable of handling 30 tons of bulk material per hour from ship hold to conveyor hoppers.



Clark Control panel for hoist, bucket, bridge and trolley motions.

Look to CLARK for safe, high-efficiency low maintenance CRANE CONTROL

Clark designs and builds control specifically to meet the basic requirements of crane operation: safety, smoothness, efficiency, low maintenance and long life. As a major supplier of all types of engineered heavy-duty industrial control for over 30 years, The Clark Controller Company has pioneered and developed many of the advancements in modern crane control. Among these, for dc cranes, are a proven-dependable dynamic-lowering circuit for the hoist and an exclusive plugging relay design for greater motor protection when reversing bridge or trolley motions. Also outstanding in Clark dc crane controls, are the exclusive "Vari-Time" relays and contactors with built-in, hermetically-sealed adjustable time-delay elements that never require maintenance or repair, and are "guaranteed for the life of the controller".

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Here are just a few of the many Rust-Oleum differences that save *time, money, metal*—and help to make present equipment last longer.

Saves money—because the Rust-Oleum 769 Damp-Proof Red Primer goes right over sound rusted surfaces after wirebrushing rust scale and loose rust away—usually eliminating costly surface preparation. So easy to use that one man often does the work of two. *Saves money, too*—because Rust-Oleum provides approximately 30% more coverage than most ordinary materials, depending upon the condition and porosity of the surface. *Saves metal*—because Rust-Oleum's specially-processed fish oil vehicle penetrates rust to bare metal, driving out the air and moisture. Attractive Rust-Oleum finish coatings provide lasting beauty in the color of your choice.

See *proof* of performance with your own Rust-Oleum Test Sample. See its smooth, self-leveling action... see how you can save rusted metal and beautify as you protect. Your letterhead attached to the coupon on the opposite page will bring your FREE Test Sample. We want you to try it yourself under your own rust-producing conditions. One brushful tells more than a thousand words.

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AVAILABLE IN PRACTICALLY ALL COLORS

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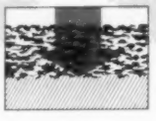
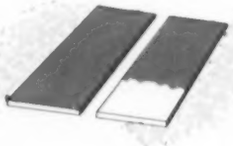


PENETRATES RUST TO BARE METAL



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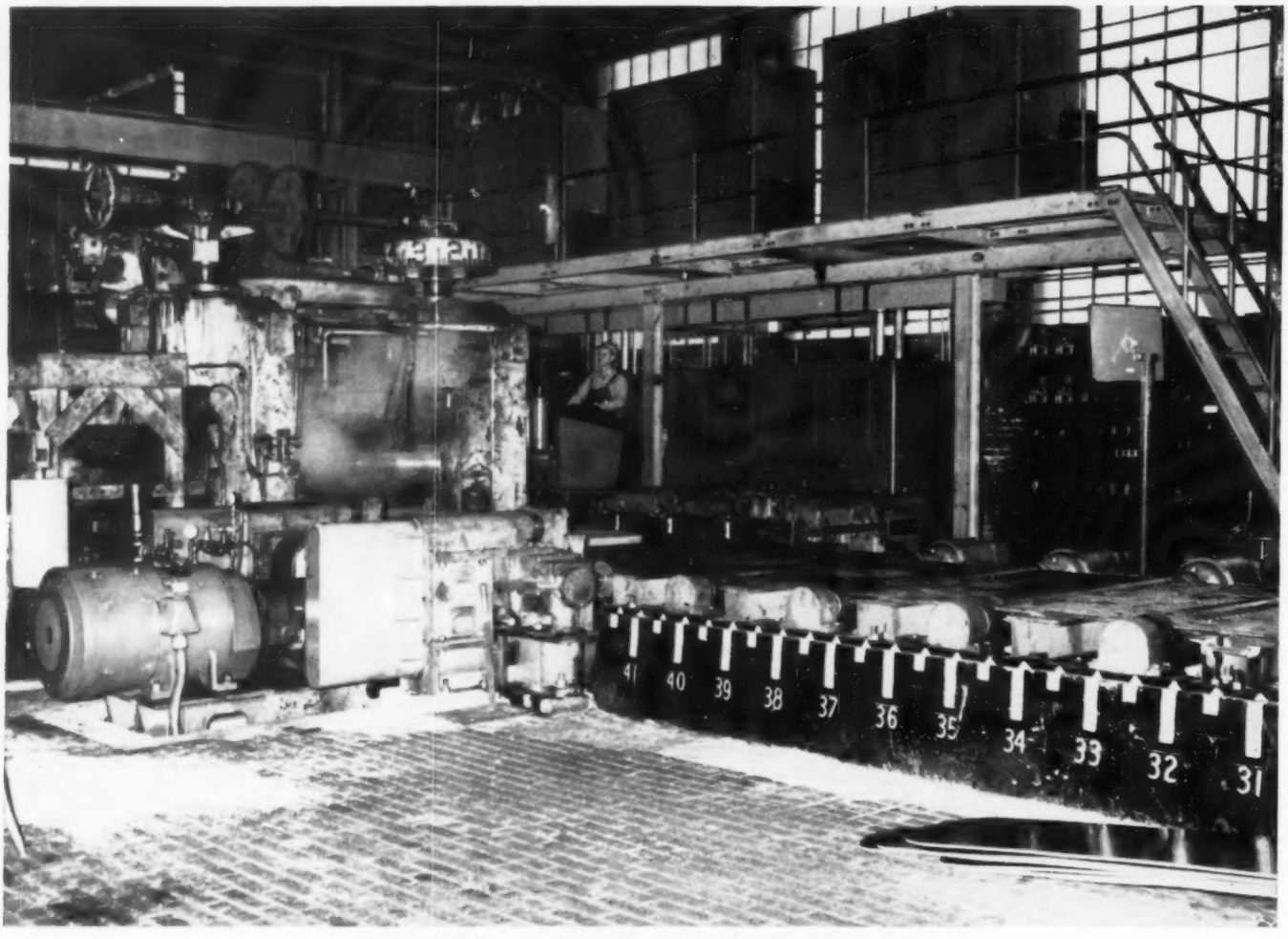

Packaged M-G sets and controls are located right at the hot mill in Revere Copper and Brass, Incorporated's New Bedford, Mass. plant

Reliance Packaged Drives cut Modernization Cost 20%

Instead of one large motor-generator set, Revere Copper and Brass, Incorporated used five packaged V★S Drives to power the edger and tables on their rebuilt hot mill.

Reliance Drives package the M-G sets with controls and put them right at the mill itself. Conduit runs are of minimum length, which reduced not only material costs but construction time.

Control installation was vastly simplified. Each V★S Unit was prewired and pretested before shipping. The complete V★S Cabinets had only to be set in place and connected. Extra construction was not required for a generator room.

Packaged V★S Drives cut costs for Revere and gave more flexibility of operation and greater ease of maintenance. Reliance Packaged Drives will reduce drive installation and operating costs for any type of mill.

For complete details contact your Reliance representative, or write today for Bulletin No. D-2506. L-1586

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THE LEE WILSON OPENED COIL ANNEALER . . . a high-volume continuous coil annealing furnace that has all the advantages of continuous strand annealing with none of the disadvantages. It requires far less area and installation costs. It is easier to maintain. It anneals with a uniform thoroughness unmatched by any other method. *It exposes 400 times more area to heating than conventional coil furnaces* and delivers greater tonnages than modern day continuous furnaces. Its operating costs per ton are much less.

The Lee Wilson Opened Coil Annealer is the result of 25 years of annealing furnace development in which Wilson engineers have played leading roles. It is a thoroughly tested system about which we're sure progressive annealing engineers will want to know more. To do so, contact a Lee Wilson sales engineer soon.

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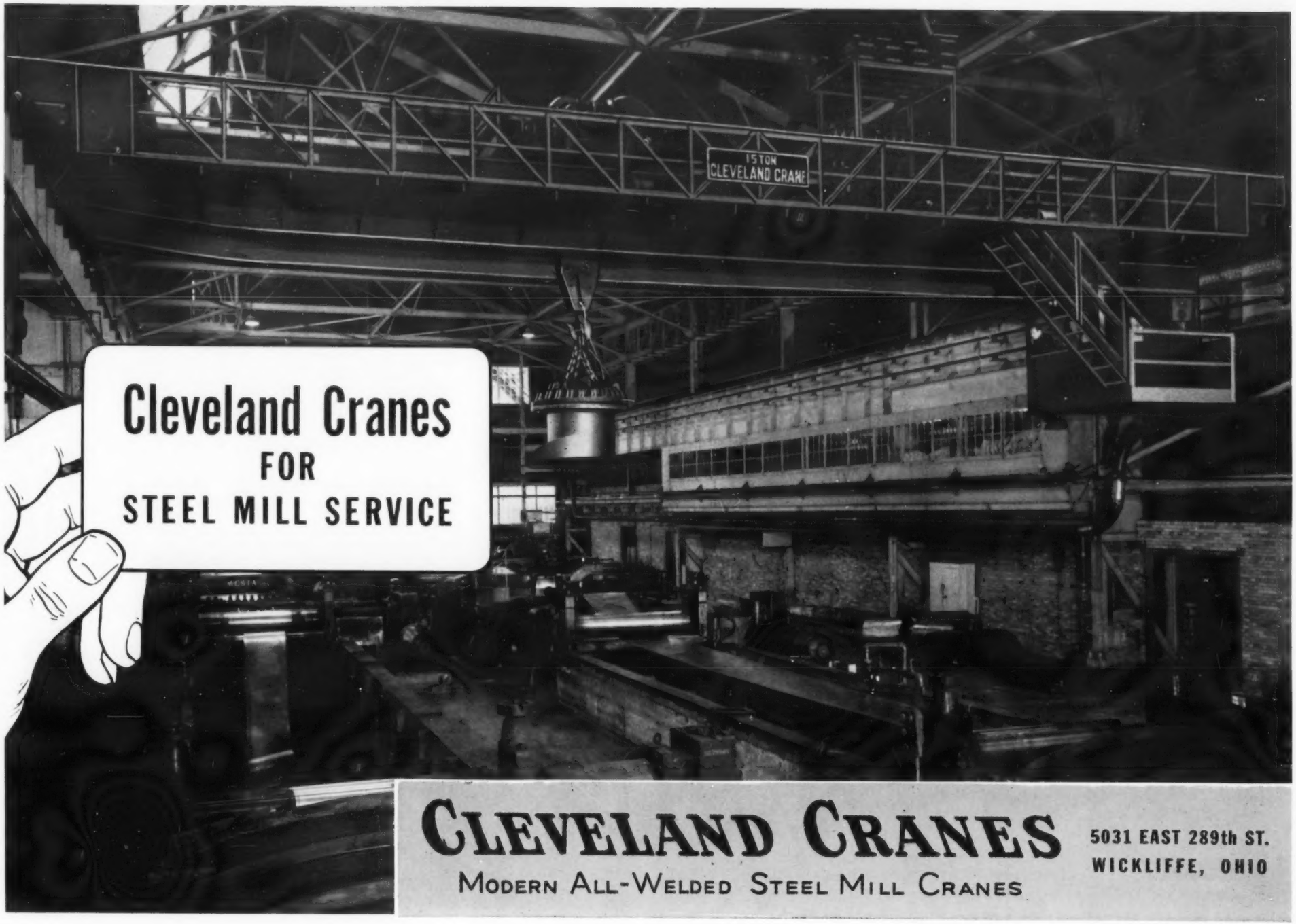
MAKE THE BEST METALS BETTER

* ORIGINATORS AND LEADING PRODUCERS OF SINGLE-STACK RADIANT TUBE FURNACES



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FOR
STEEL MILL SERVICE

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

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Crops and Shorts

△ The 1958 spring conference of the Association of Iron and Steel Engineers, held at the Dinkler-Tutwiler Hotel in Birmingham, Ala., April 21-22-23, ended with a total registration of 602 men. Attendance was good at the seven technical sessions, and interest was high in the papers presented. About 420 men attended the dinner at which Norman C. Michels, vice president of engineering, Tennessee Coal and Iron Div., United States Steel Corp., spoke. Almost 200 made the trip to Gadsden, where they toured Republic Steel Corp.'s Gulfsteel plant.

△ First quarter earnings in the steel industry present a mixed picture. Some companies operated at a loss, some showed profits up to as high as 60 per cent of those of the first quarter of 1957. Few made enough to cover their going dividend rate, but the tendency wisely seems to be toward maintaining the dividend wherever possible.

The figures are particularly interesting in view of the recent statement by United Steel Workers' David J. McDonald that the industry can make money at 25 per cent operations. Maybe it's all a matter of definition—or maybe Mr. McDonald forgot about the stockholders.

△ A recent column by Drew Pearson opened thus: "Word that comes from the oak-paneled walls of the Duquesne Club in Pittsburgh is that the iron and steel moguls will not hump themselves to break the recession until they know that a tax cut is around the corner." Mr. Pearson says that if President Eisenhower really "made the pitch" to George M. Humphrey, General Lucius Clay, Sidney Weinberg, and the Mellon, Pew and Rockefeller families, "it seems likely he could get the iron and steel industry going full blast again."

It would seem that Mr. Pearson has the satellite ahead of the planet. Steel is not an end product, but only a material used to make such products. We are sure that the fabricators of such products need only hint they want some steel and they'll get it—but quick! We are equally sure that the fabricators will buy steel if customers show up to buy the manufactured products which are bulging the warehouse walls.

Rather than taking pot-shots at "moguls" and involving the poor old Sixth Avenue Chowder and Marching Society, Mr. Pearson might try persuading his readers to buy such things as they need and would normally buy now.

△ One thing still untouched by automatic machines is the income tax. It's still chiseled and filed.

△ Annual steel capacities of the various producing districts are reported by the American Iron and Steel Institute as Eastern, 30,506,000 tons; Pittsburgh-Youngstown, 48,975,000 tons; Cleveland-Detroit, 14,936,000 tons; Chicago, 30,136,000 tons; Southern, 8,292,000 tons; and Western, 7,898,000 tons.

△ The Bulletin of the Sangamon (Ill.) County Medical society lists five signs by which you can diagnose old age in yourself:

1. When you look at the menu before you look at the waitress.
2. When you wait for a crowded escalator rather than walk up the empty stairs.
3. When an "8" looks like a "3" and a "3" looks like an "8."
4. When you would rather sit on the beach than go into the water.
5. When you leave a good party early because you do not want to feel bad the next day.

△ In 1957, 38,700 Americans were killed and 2,525,000 injured in traffic accidents.

△ Republic Steel Corp.'s Warren blast furnace (28 ft diam) produced a record 62,092 net tons of iron in March.

△ Imports of reinforcing bar from Japan and increasing shipments of nails and barbed wire from France and Germany tend to bear out the statement by Roger M. Blough, chairman of United States Steel Corp., that American workmen are pricing themselves out of the market.

The average hourly rate for wage earners in the iron and steel industry is now about $3.09, plus an estimated 30 cents an hour for pensions, social security, insurance, etc. The mid-year increase called for by the existing contract will further diminish the ability to compete with foreign production.

△ Advertising Age says: "The marketing of automobiles has now reached a condition approximately like the economic jungle of a Middle East bazaar, in which everything, including price, is a mystery.

△ Addressing the directors of the Indiana State Chamber of Commerce, A. S. Glossbrenner, president of Youngstown Sheet and Tube Co., said: "Since World War II our collective bargaining agreements have been made in an environment of economic power, not reason. It is time we came to our senses, looked about us, and tailored these important decisions to fit the circumstances."

Current happenings indicate that union leaders haven't changed their way of thinking, but managements, without the nice profits that strikes would shut off, seem to be stiffening their resistance to exorbitant demands. That's a good sign.

△ Sponge iron is now being produced in the United States, and is available for melting stock for high quality steel production, primarily in acid open hearths, induction furnaces and basic electric arc furnaces. It is sold in 3-lb briquets and is said to be 96 per cent reduced and very pure.

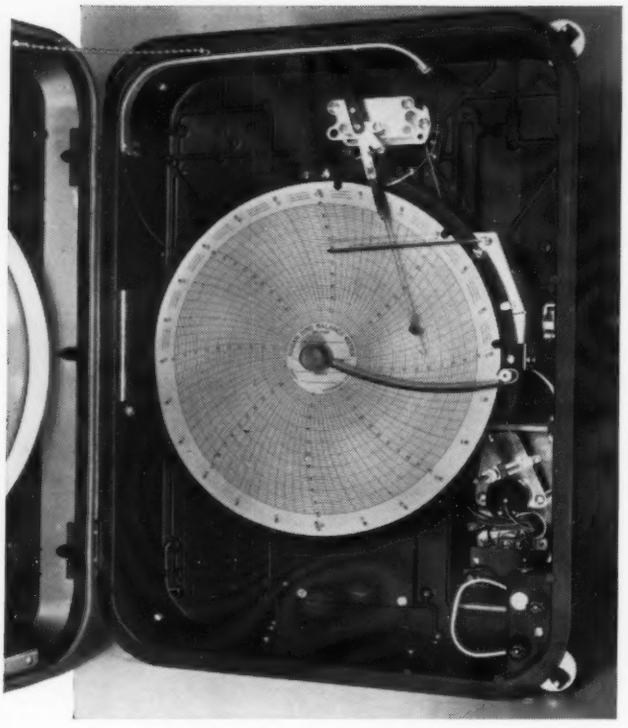
△ It seems there are wider differences between factions within our political parties than there are between the parties.

RING BALANCE FEATURES No. 4

ELECTRIC TRANSMISSION

with the versatile new PowrLog

ELECTRONIC RECEIVER



Complete assembly with amplifier in place. Flow integrator may be added for complete records.

The Hagan PowrLog Electronic Receiver brings a new standard of accuracy and dependability to the remote transmission of all standard variables. In applications where the transmitter is a Ring Balance meter equipped with slide wire, the PowrLog receiver can record, integrate and indicate fluid flow with or without compensation for pressure and temperature, fluid density, liquid level in open or closed vessels, boiler drum water level. Used with suitable amplifiers, the field of application widens to include temperature, heat exchange and other variables.

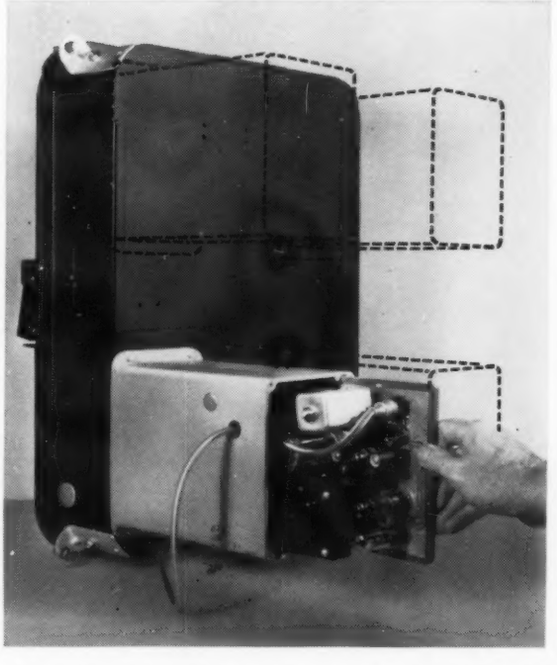
Interchangeable, plug-in, input boxes quickly adapt the PowrLog to operation with AC or DC inputs. Up to four records can be made simultaneously or control can be accomplished through coupling to the Ring Balance pneumatic transmitter-controller.

Unaffected by mechanical friction or power supply fluctuations, the PowrLog offers these operating characteristics:

Resolution	0.15% of full scale
Repeatability	0.25% full scale
Over-all Accuracy	0.5% full scale
Pen Travel Time	2 seconds full scale (0.5 sec./inch)

Input Ranges:

AC Bridge	1000 ohm transmission potentiometer
DC Potentiometer	0-0.1 v. to 0-1.3 v.
DC Voltmeter	500 volts maximum



Printed circuit amplifier chassis slides readily into housing. Note that as many as four units may be used in a single instrument case.

Remember, the Hagan Ring Balance meter offers you all these features, too:

1. Ease of calibration under operating static pressures with factory calibrated check weights matched to each meter. No more four-story water columns and telephones!
2. Safe operation with rings rated at 2,500, 6,000, 15,000 psig. No gaskets, no stuffing boxes.
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5. Wide range computation and/or compensation by means of built-in, easily checked mechanisms available on most models.
6. Any Ring Balance meter can be equipped with slide wire for operation with data-logging devices and for transmission to the PowrLog.

For full details on the Hagan PowrLog, write for Bulletin MSP 149.

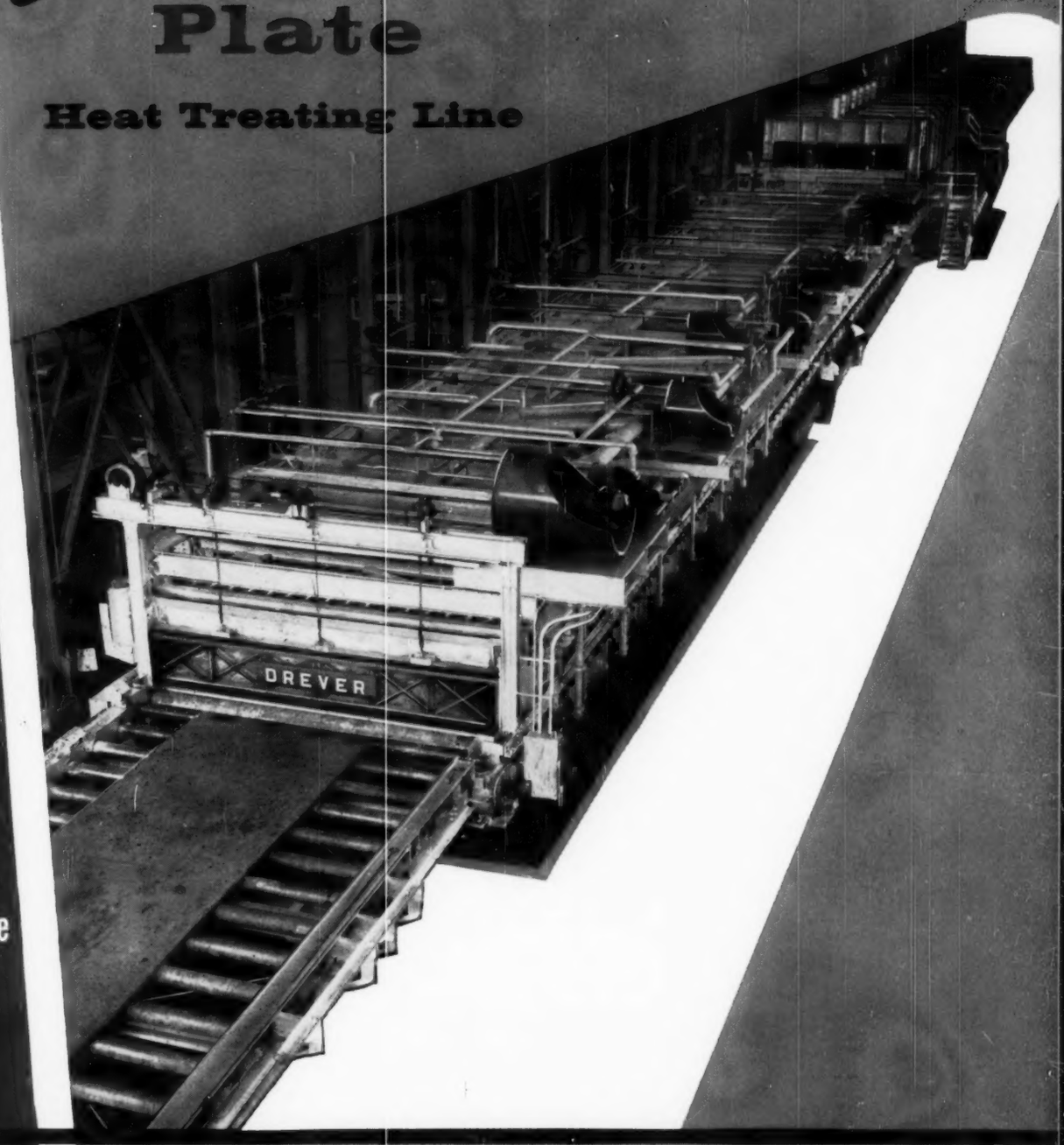
HAGAN CHEMICALS & CONTROLS, INC.

HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY, HALL LABORATORIES
IN CANADA: HAGAN CORPORATION (CANADA) LIMITED, TORONTO

DREVER

Plate

Heat Treating Line



Shown is the charging end of a 145'-0" hardening furnace. In the background can be seen a 2500 ton pressure quench, 200'-0" draw furnace and the operator's control pulpit.

This roller-hearth plate heat treating line, known to be the largest of its type, has a capacity to treat plate up to 21-1/2 tons per hour. The equipment is capable of handling plate sizes up to 172" wide x 3" thick x 600" long.

The furnace rolls are 25/12 modified alloy and are designed for a maximum furnace operating temperature of 1650° F.

The maximum fuel capacity for both furnaces is 122,000,000 Btu's per hour.

The entire line is under the control of a single operator. Full utilization of strategically located TV cameras enables the operator to have full control over all operations.

DREVER COMPANY

RED LION ROAD and PHILMONT AVE., BETHAYRES, PA.

Johns-Manville Insulating Fire

put physical and thermal properties *in proper balance!*

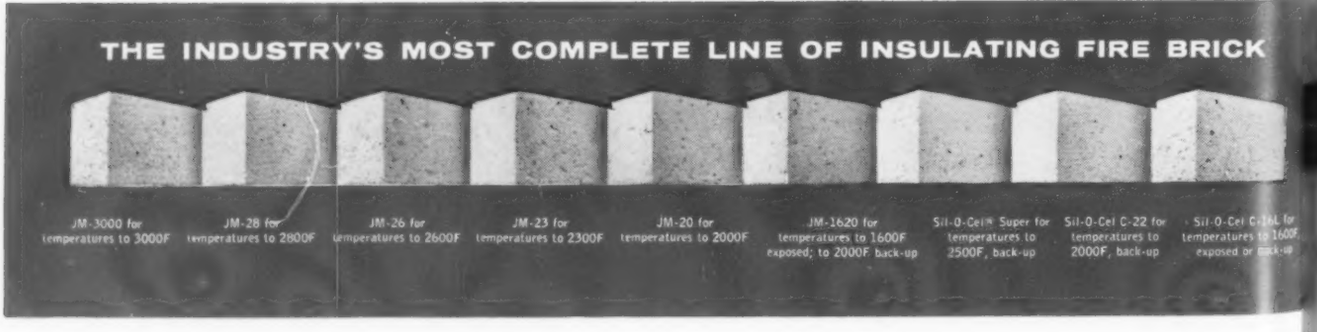
. . . provide essential high-temperature resistance and low conductivity . . . yet maintain high load-bearing strength with low spalling!

Only Johns-Manville's insulating fire brick family offers the right combination of properties to meet the diversified requirements of modern furnace construction.

Johns-Manville's nine different insulating fire brick mean you never have to settle for a brick that's nearly right! Instead you choose the one insulating fire brick or combination of brick that best meets your specific requirements for temperature resistance, load-bearing strength, conductivity and density.

Johns-Manville has two strategically located plants for the production of insulating fire brick: Lompoc, California and Zelienople, Pennsylvania. Insulating fire brick and other Refractory Products are available from the stocks of Authorized J-M distributors in key industrial areas.

For further information, call your nearest J-M representative. Or write for brochure IN-115A to Johns-Manville, Box 14, New York 16, N.Y. In Canada, Port Credit, Ontario.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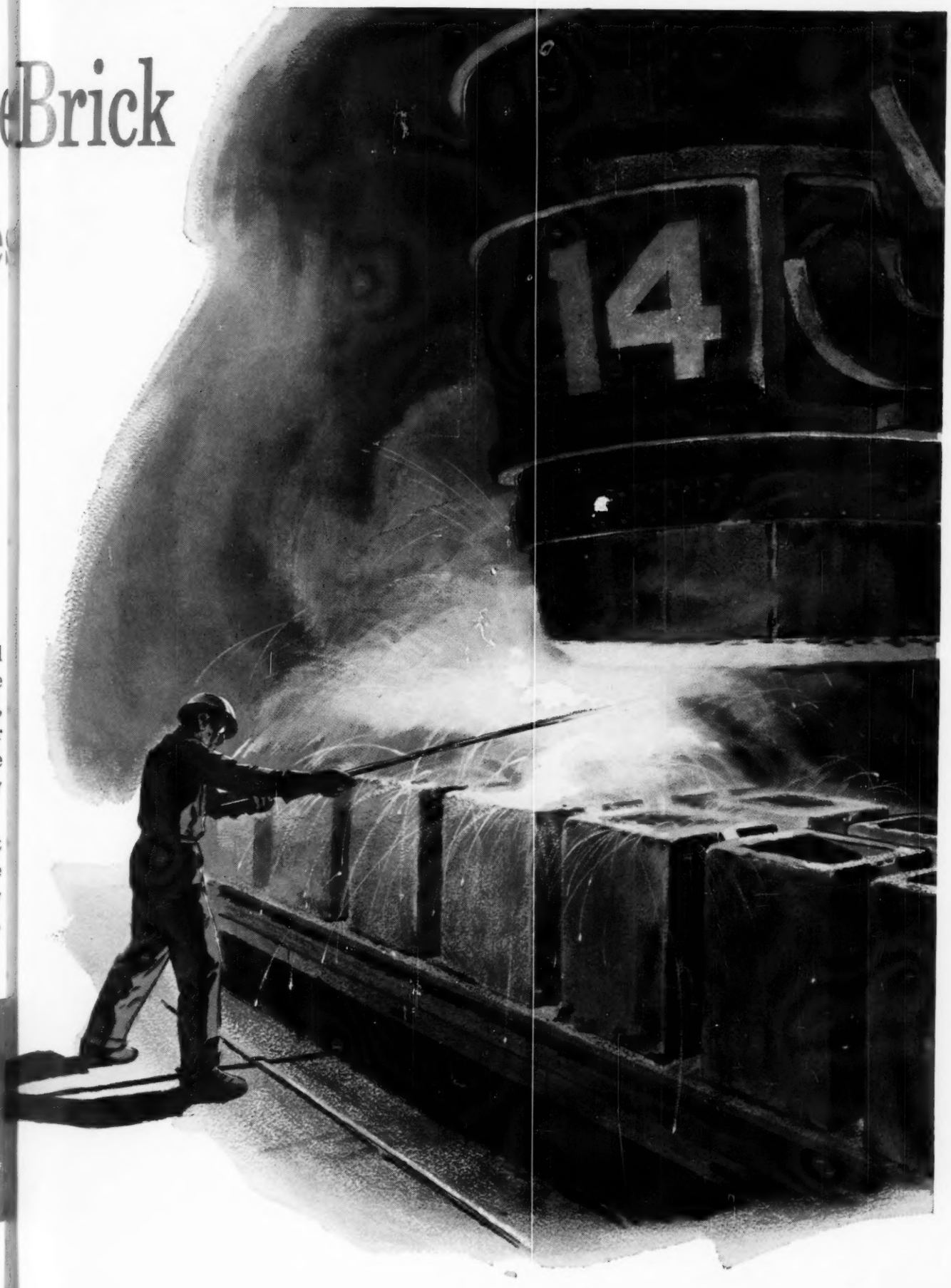
JM-28 for temperatures to 2800F
JM-26 for temperatures to 2600F
JM-23 for temperatures to 2300F
JM-20 for temperatures to 2000F
JM-1620 for temperatures to 1600F exposed; to 2000F back-up
Sil-O-Cel® Super for temperatures to 2500F, back-up
Sil-O-Cel C-22 for temperatures to 2000F, back-up
Sil-O-Cel C-16L for temperatures to 1600F exposed or back-up

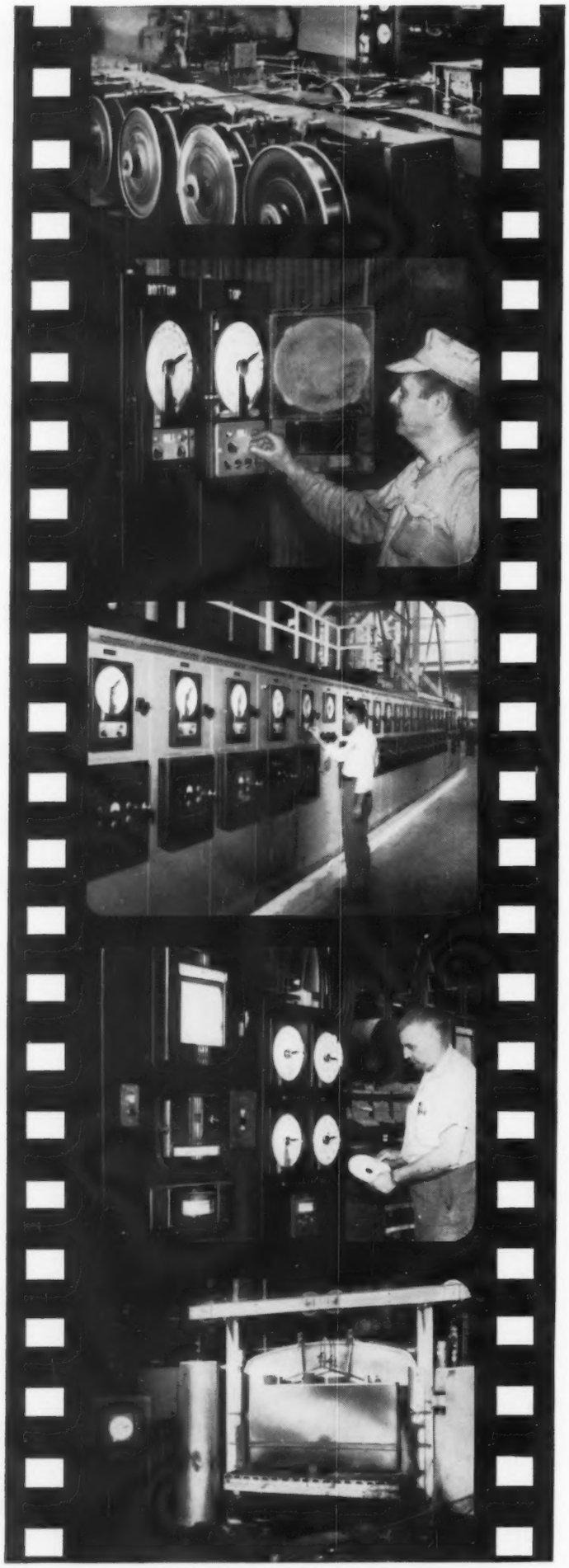
JOHNS-MANVILLE JM PRODUCTS

Johns-Manville REFRACTORY and N



Fire Brick

and INSULATING REFRACTORY PRODUCTS



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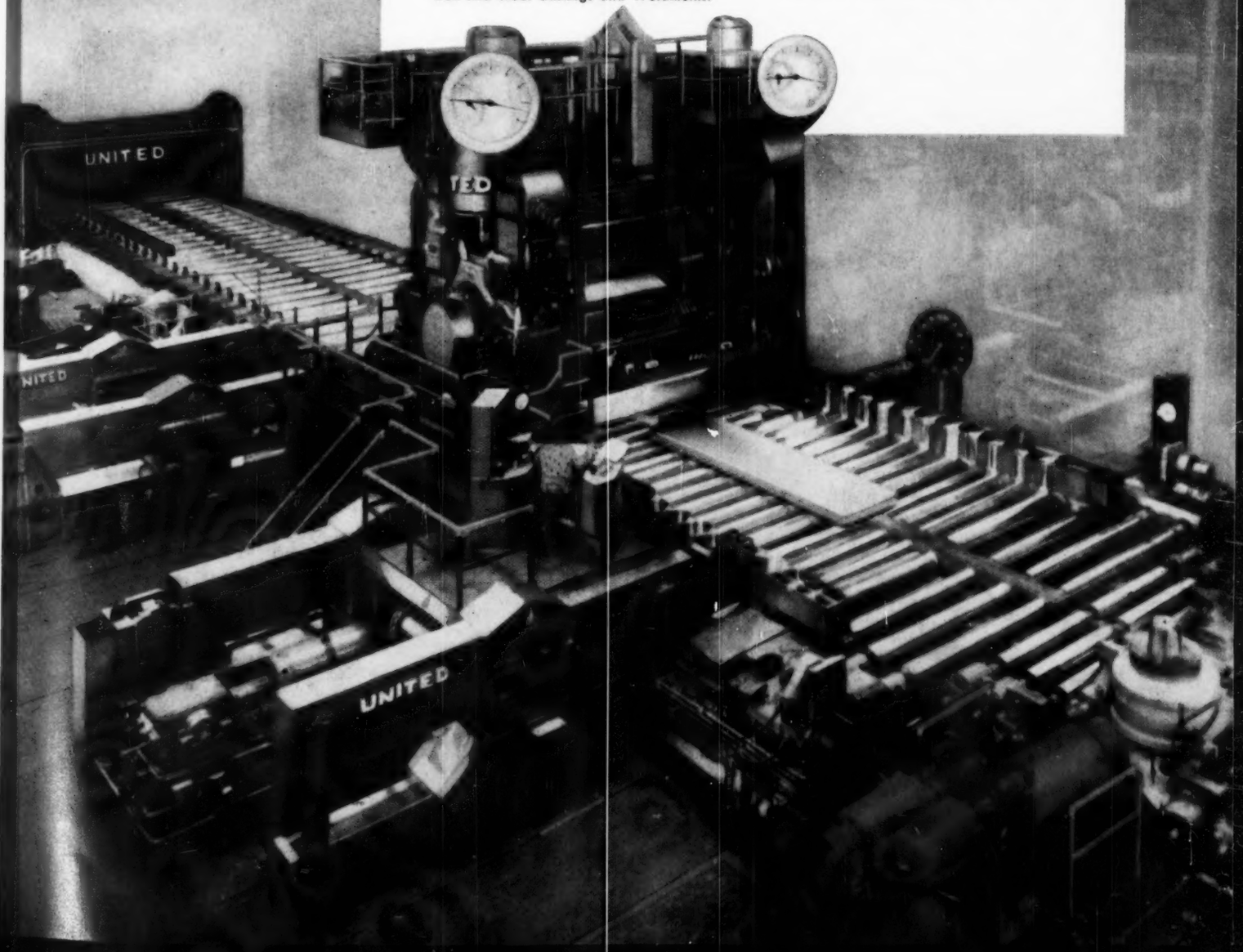


Unmasking a Myth* about OXYGEN

the Myth:

Reliability of oxygen supply is possible only through hauled-in liquid oxygen generated at remote central stations.

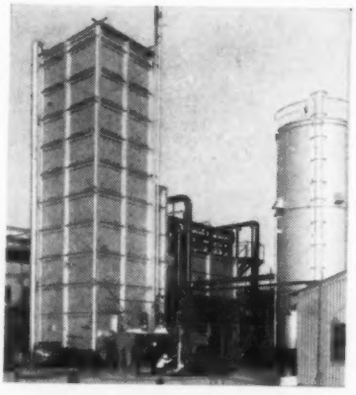
the Fact:

Operating records prove that Air Products on-site systems provide complete reliability.

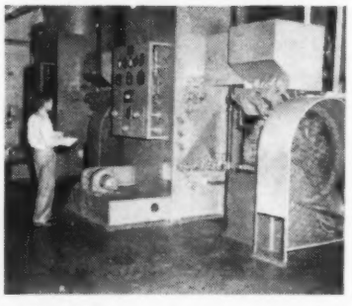
In 17 years, no Air Products customer has ever been without oxygen.

the Reasons:

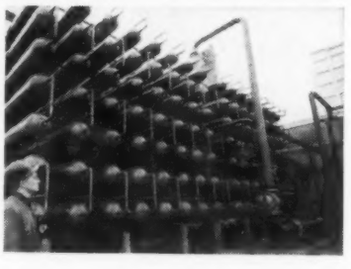
1. Single Air Products generators regularly operate one year without any shutdown whatsoever.



2. Multiple generator installations assure constant supply regardless of shutdowns for maintenance and defrosting.



3. Generator-fed storage systems — for both liquid and gas — provide instantly available reserves as positive insurance against *any* shutdown. These systems may be made independent even of outside power supplies... can contain many days' supply of oxygen.



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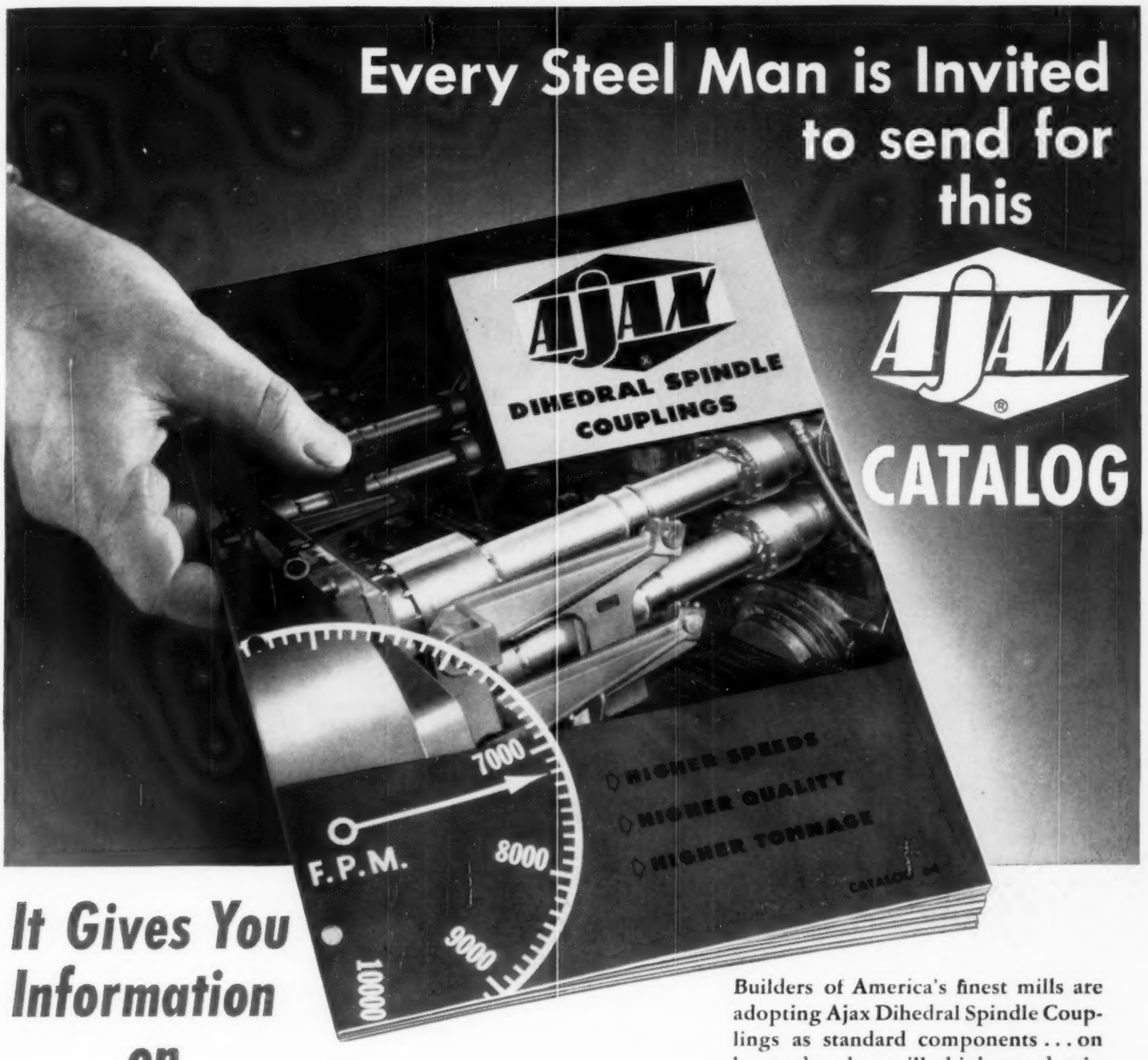

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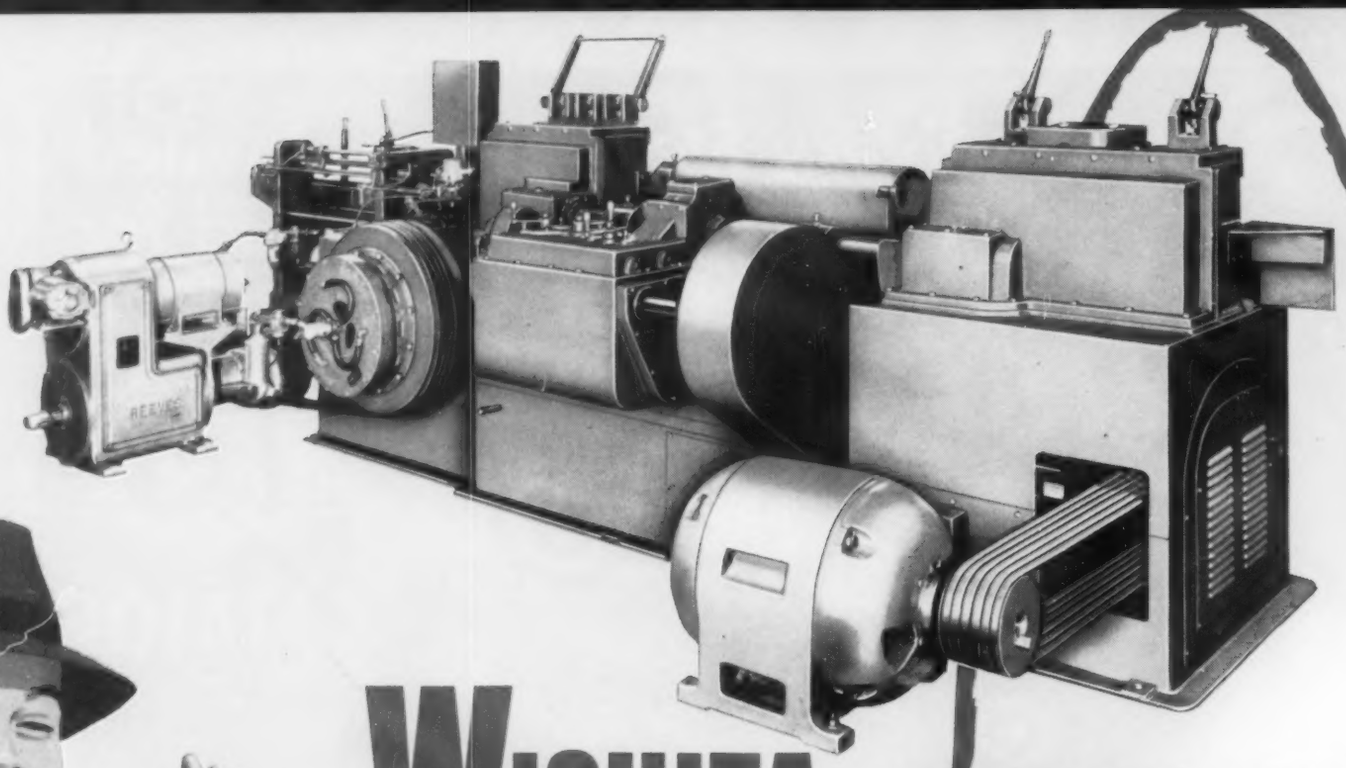

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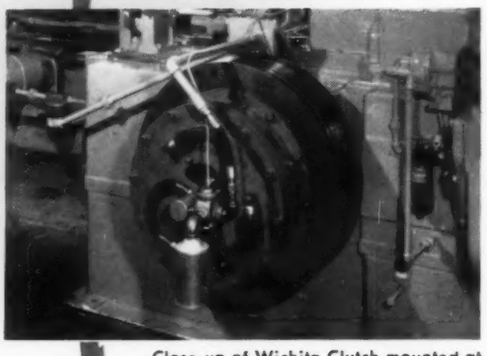
CLUTCHES AND BRAKES MEAN

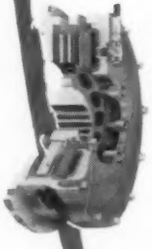
Better Quality Control

on Lewis Automatic Wire Straightening and Cutting Machines!

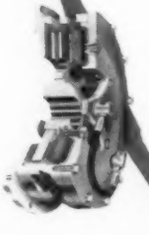
"After making a study of available air clutches and brakes we decided on Wichita for several reasons," states F. J. Rybak, Vice President of The Lewis Machine Co., Cleveland, Ohio. "We found that Wichita Units provided the main features needed to improve quality – smooth, fast engagement due to low air consumption. Higher flywheel speeds are thus possible and by utilizing a Variable Speed Drive, we can perfectly synchronize our cut-off speed with the wire feed. We have also incorporated a Wichita Air-Tube Brake to eliminate the conventional drag brake which unnecessarily loaded the machine. In consequence, this Wichita Clutch and Brake System gives our machines BETTER QUALITY CONTROL. Now it is possible to produce perfectly straightened and accurately cut rod without "spot swell" which has long been a problem in the wire industry."



Close-up of Wichita Clutch mounted at rear of Lewis No. 11-F Travel Cut.



Wichita Low Inertia Air-Set Disc Brake.



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Dominion Power Press Equipment, Ltd., Burlington, Ontario, Canada
R. E. Kunz, Seattle 4, Wash.
W. G. Ballantyne Co., Portland 4, Ore.
Bates Sales Co., St. Louis 1, Mo.

patent reviews

By MELVIN NORD, Patent Attorney, Detroit, Mich.

Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents reviewed cover period December 10, 1957 through December 31, 1957.

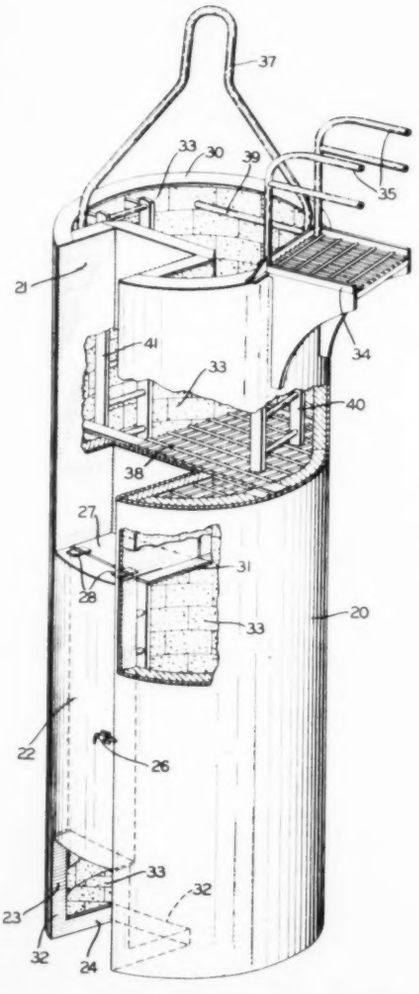
PRODUCTION OF STEEL FROM HIGH-CHROMIUM ORES

△ U. S. 2,816,017, issued Dec. 10, 1957 to Wilhelm Wolf and Wilhelm vor dem Esche, assigned to Hoesch-Westfalenhutte A.G., describes a method of producing steels having a low chromium content from iron ores having a high chromium content.

A pig iron is first produced which contains more than 0.2 per cent chromium and less than 0.8 per cent manganese. This requires the blending of one or more ores with the high-chromium ore. This pig iron is subjected to a pre-refining process, by blowing to a chromium content below 0.1 per cent, and is then refined in a usual converting process to form steel.

The blowing can be carried out either with air or oxygen. It must be conducted at substantially a constant temperature. In order to prevent an increase in temperature, heat consuming oxides are added to the bath in either the gaseous, liquid or solid form.

Figure 1

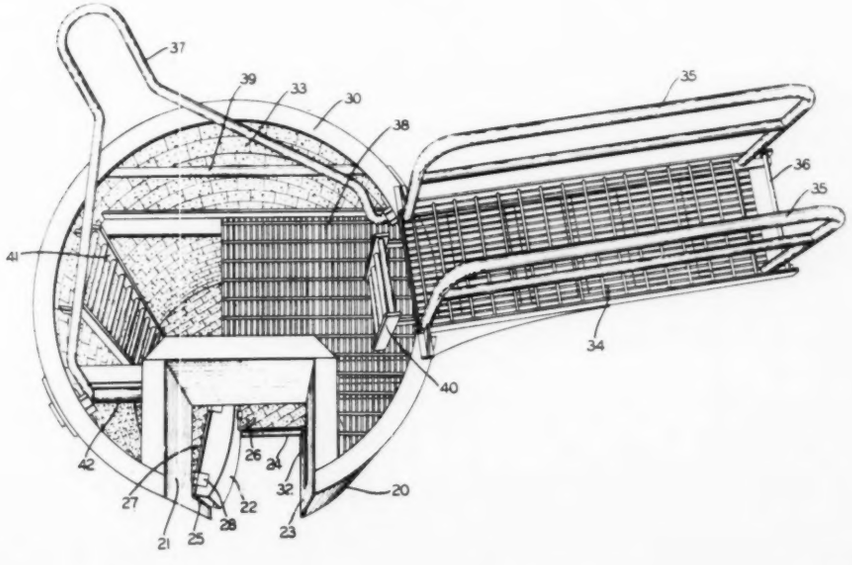


LADLE MAINTENANCE CAGE

△ U. S. 2,816,335, issued Dec. 17, 1957 to June H. Reighart, describes a cage to be placed within a ladle during maintenance work, to shield the workman from the intense heat of the ladle while he is replacing the pouring nozzle and setting the stopper rod in it.

Figures 1 and 2 show the maintenance cage in two views. It consists basically of a cylindrical insulating brick-lined metal cage 20 of the same height as the ladle, with a vertical stopper rod setting well 21 formed in one side of the shell (extending from the top to below

Figure 2



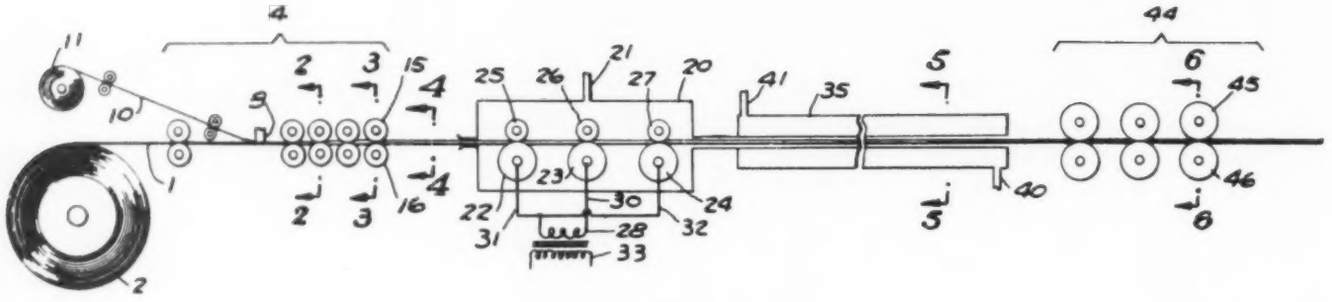


Figure 3

the midpoint of the cage), an access door 22 beneath the well, and a stopper rod setting platform 38.

MANUFACTURE OF TUBE FROM STRIP METAL STOCK

△ U. S. 2,816,356, issued Dec. 17, 1957 to Raymond H. Hobrock and assigned to Bundy Tubing Co., provides a method for making tubing from bare strip stock, thus dispensing with the necessity of applying the bonding metal to the strip in the form of a coating or film. Instead, the bonding metal is introduced into the tube in the form of a strip or wire. The tube is subjected to a heat treatment to melt the bonding metal. The principal difficulty encountered is that tubing so fashioned and which is round in cross section twists on its axis. This is due apparently to different metal conditions as to relative hardness and softness and to various strains set up in the metal. As a result, the seam running lengthwise of the tube changes its position. When the strip or wire of bonding metal is rendered molten, it gravitates to the bottom of the tube, and if the seam is at the bottom of the tube, the bonding metal will flow between the interfaces to unite the interfaces upon solidification. However, if the tube twists so that in different longitudinal increments of the tube the seam is displaced upwardly from the bottom of the tube, the molten metal cannot flow in between the interfaces.

In this invention the tubing is made in an inverted manner. The tube is fashioned into a noncircular form in cross section so that it can be guided and held in a position with the seam at the lower portion of the tube so that molten metal may flow in between the interfaces. After the bonding of the interfaces, the tubing is subjected to a treatment to give it a substantially round or circular form in cross section.

As shown in Figure 3, the strip 1 is drawn from a supply coil 2 and is passed through a tube mill 4. The tube mill has forming rolls which fashions the strip transversely into hollow cross-sectional form. The strip is formed about a mandrel which is held by a bracket 8. This mandrel is hollow and a strip or wire 10 of bonding metal is drawn from a supply roll 11 and fed into the mandrel.

The strip and tube are moved continuously, and as the tube emerges from the tube mill it enters a heating zone. This is in the form of a housing 20 into which a nonoxidizing or reducing gas enters through a pipe 21. This heating zone is of the electrical resistance variety. There are three roller electrodes 22, 23 and 24 with backup rolls 25, 26 and 27.

As the tubing moves through the heating zone, it is heated by electrical resistance to a temperature adequate for melting the bonded metal. The molten bonding metal gravitates to the bottom of the elongated tube and since the seam is held at the bottom, the metal flows in between the interfaces. The molten metal will quickly traverse the entire interfacial area between the plies thus flowing throughout the 360 degrees. This is due to capillarity. The metal will not flow out from between the interfaces which intersect the outer surface of the tube at the edge because the capillary space ceases at that point.

The tube leaves the heating zone and enters a cooler 35. This cooler is of the jacketed type having an outer casing, and an inner casing, through which the tube travels. Cooling water is passed between the jackets, and may be introduced through a pipe 40 and discharged from pipe 41. The gas introduced through the pipe 21 may flow both upstream and downstream with some of the gas burning off at the inlet to the heating chamber and some discharging from the outlet end of the cooler.

With continuous movement, the tube now passes through a sizing and rounding unit 44. It consists of a series of suitably formed rolls which engage the tube and change its elongate cross sectional form into founded form. The final rolls are indicated at 45 and 46.

SCARFING OF STEEL BLOOMS

△ U. S. 2,817,611, issued Dec. 24, 1957 to George V. Slottman and assigned to Air Reduction Co., Inc., describes a method of scarfing, for use in high-speed steel mills, in which the scarfing can be effected without stopping each bloom for the step of preheating.

This object is accomplished by effecting the required preheating while the bloom moves forward continuously, at a speed which at least approaches the high speed at which it is being moved after the prior treating operation. In this manner, scarfing is done without stopping the bloom and a continuous succession of blooms are obtained at a high-speed production rate. As a consequence, the disadvantage, encountered in prior practice, of the scarfing operation being a limiting factor on the mill schedule due to the time required for stopping, positioning and preheating the bloom, is avoided.

REFINING OF PIG IRON

△ U. S. 2,817,584, issued Dec. 24, 1957 to Theodor Kootz and Heinrich Rellermeyer, assigned to August Thyssen-Hutte A. G., et al., describes an improvement in the oxygen process for refining steel.

In contrast to the conventional

Self-aligning

FOR LONGER LIFE

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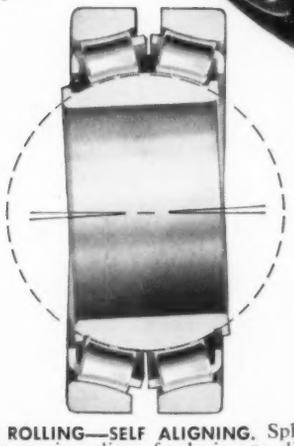

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conversion processes, e.g., the bessemer process in which the air or other oxygen-containing gas is blown through the molten iron, the refining methods in which the air or other oxygen-containing gas is injected directly at the molten metal surface can achieve an adequate dephosphorization only if the dephosphorization is completed prior to the completion of the decarbonization of the pig iron.

However, it is very difficult to control the refining process so that the dephosphorization is completed before the end of the decarbonization, and methods in which this is accomplished by first dephosphorizing without substantially decarbonizing and subsequently decarbonizing are time-consuming and consequently expensive.

It is therefore an object of the present invention to provide a method of refining pig iron whereby the dephosphorization and decarbonization can proceed substantially simultaneously while still achieving adequate, and in fact, excellent dephosphorization.

According to this method, the decarbonization of the molten pig iron is at first retarded by maintaining a relatively large distance between the nozzle opening of the lance and the upper surface of the molten metal bath, or by utilizing a relatively low oxygen pressure. This is continued until after the formation of an iron oxide-rich lime slag which can slagify most of the phosphorous. Then the decarbonization is started by reversing the process conditions, so that a smaller distance between the nozzle opening and the surface of the bath is maintained or the oxygen pressure is increased. In this way the carbon reduces the surplus iron oxide in the slag, so that at the end of the refining, an iron-poor phosphate slag similar to the one obtained in the usual refining method is obtained.

APPARATUS FOR MELTING IRON IN A CUPOLA

△ U. S. 2,817,508, issued Dec. 24, 1957 to Harold W. Schwengel and assigned to Modern Equipment Co., provides an improved method of melting iron in a cupola, which provides accurate control of the temperature within the cupola, and hence accurate control of the quality of the iron produced.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or assignee
2,815,691	12/10/57	Rolling mill repeater	United States Steel Corp.
2,816,016	12/10/57	Pelletizing iron ore concentrates	Erie Mining Co.
2,816,018	12/10/57	Production of steel from high-phosphorus pig iron	Karl Ziegler
2,816,336	12/17/57	Sand mold containing a chill section	American Steel Foundries
2,816,467	12/17/57	Rolling mill construction	Sandvikens Jernverks Aktieboleg
2,816,751	12/17/57	Controlled atmosphere furnace muffle	Standard Oil Co. (Ind.)
2,816,829	12/17/57	Nodular iron manufacture	Ford Motor Co.
2,816,830	12/17/57	Alloy steel for use at high temperatures.	The Carpenter Steel Co.
2,817,507	12/24/57	Forge furnaces for heating metal billets.	The Gas Machinery Co.
2,817,509	12/24/57	Lined crucibles for molten metal	Electro Refractories & Abrasives Corp.
2,817,610	12/24/57	Production of black oxide coatings on steel and iron	Isaac L. Newell and Ernest A. Walen
2,818,014	12/31/57	Slab marking apparatus	Jones & Laughlin Steel Corp.
2,818,248	12/31/57	Refractory block and ladle lining construction	Paul S. Kelsey
2,818,328	12/31/57	Production of powdered iron	Charles B. Francis
2,818,360	12/31/57	Aluminum cladding of ferrous base metal	Jones & Laughlin Steel Corp.

The cupola is sealed off from the ambient atmosphere during operation. Accurately controlled amounts of air are supplied to the cupola at the bottom, at a predetermined temperature. The gases of combustion are withdrawn overhead at a predetermined rate to maintain uniform pressure and temperature conditions in the cupola. They are then mixed with supporting fresh air in an auxiliary combustion chamber, the heat thus produced being used to preheat the fresh air entering the bottom of the sealed cupola.

By maintaining uniform temperature conditions within the cupola in the manner described, a uniformly high quality of product results. In addition, the ignition of burnable components of the cupola gases, which are normally discharged as waste, and the utilization of the heat of the cupola gases after ignition for the purpose of preheating the fresh air entering the bottom of the cupola, results in highly efficient operation. It also makes possible the accurate control of the temperature within the cupola by the simple expedient of controlling the extent of the ignition of the burnable portions of the cupola gases.

SELF-CENTERING ROLL

△ U. S. 2,817,940, issued Dec. 31, 1957 to Edwin T. Lorig, assigned to United States Steel Corp., describes a self-centering roll for use with wide short belts and wide strip, especially of light gage.

Figure 4 is a cross-sectional view of the self-centering roll, under no-load static conditions. Figure 5 shows its operation when a belt or strip B passes beneath the roll and then up around the roll, the length of the

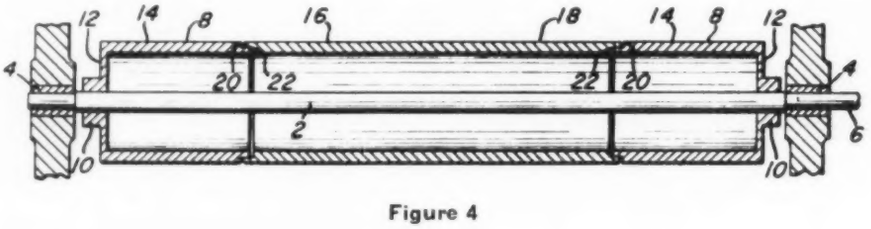
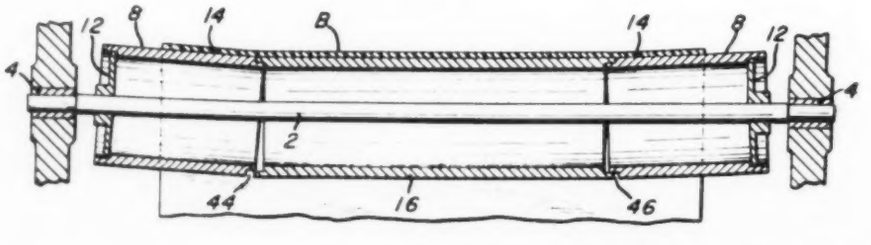
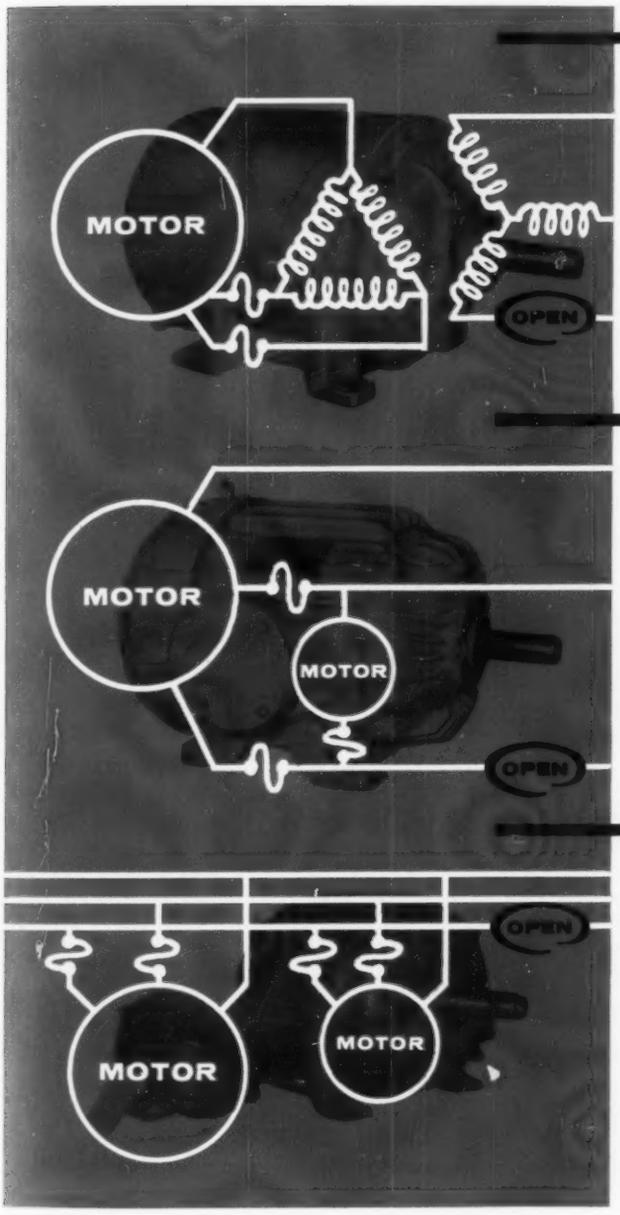


Figure 4

Figure 5



Three-Coil Overload Protection Would Have Prevented These Motor Burn-outs

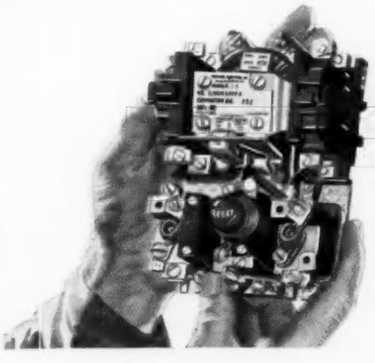


MOTOR No. 1. Even though this three-phase motor was equipped with a 2-coil overload relay, the motor burned out . . . and here's why. Like the vast majority of three-phase motors in use today, this motor took its power from a wye-delta transformer; and an open phase condition in the transformer primary caused one high and two low motor currents. The 2-coil overload relay could not save this motor because the high current was in the unprotected line. Why gamble with a motor burn-out? Insist upon 3-coil overload relays for all your three-phase motors . . . the only dependable overload protection for all open phase conditions.

MOTOR No. 2. This three-phase motor was operating at 70% full load with a 40% loaded single phase motor connected in parallel when one of the incoming power lines opened. Once again the 2-coil overload relay failed to detect any trouble. However the motor current in the winding without a thermal element rose to 152% full load current, while the current in the phases with the 2-element relay did not reach tripping value. This caused permanent damage to the motor winding. This motor could have been saved with full three-phase overload protection. Be sure your three-phase motors are completely protected from the hazards of all open phase conditions with dependable 3-coil overload relays.

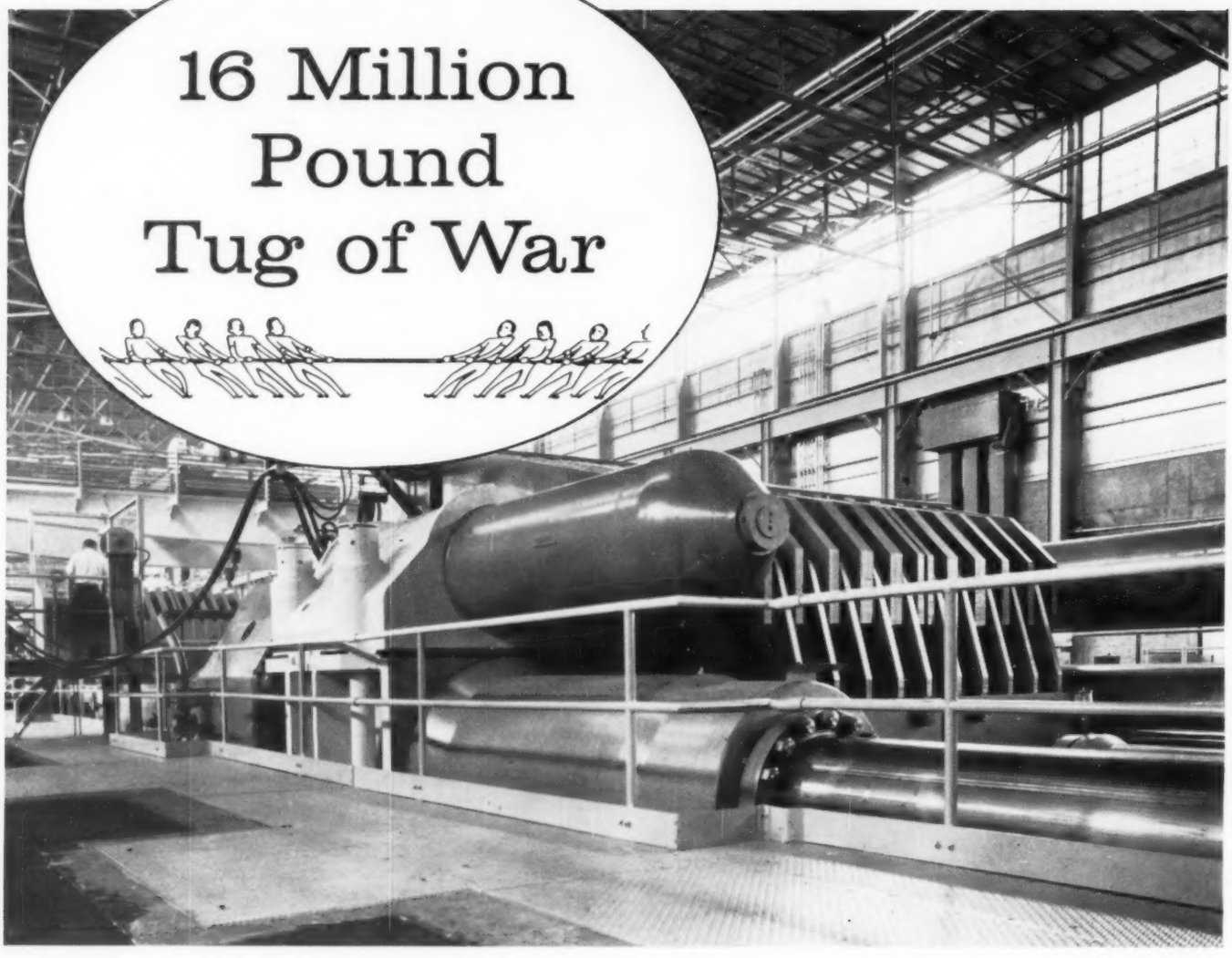
MOTOR No. 3. This 1 Hp, three-phase motor was working in parallel with a 10 Hp, three-phase motor when one of the incoming power lines opened. While the 10 Hp motor was not adversely affected by this circuit unbalance, the motor current in one line of the 1 Hp motor reached 140% full load current resulting in a burned out winding. As in the other examples, the 1 Hp motor's 2-coil overload relay proved ineffective because the overload occurred in the one line left unprotected. Don't let this happen to your motors. Insist upon 3-coil overload relays for every three-phase motor, large or small . . . only 3-coil overload relays provide dependable open phase protection under all operating conditions.

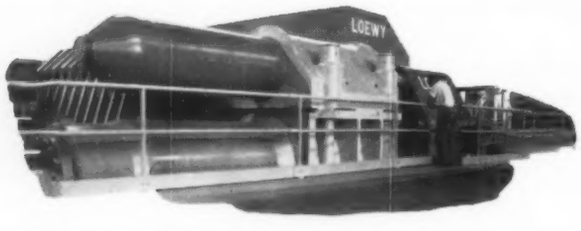
Cutler-Hammer Three-Star Motor Control offers 3-coil overload relays in all standard starter constructions and enclosures. For immediate delivery see your nearby Authorized Cutler-Hammer Distributor. Machine designers and panelbuilders, open type Cutler-Hammer Three-Star Motor Control with 3-coil overload relays require no more space than starters with only 2-coil overload relays. CUTLER-HAMMER Inc., 1269 St. Paul Ave., Milwaukee 1, Wis., *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.



CUTLER-HAMMER
MOTOR CONTROL
C-H

16 Million Pound Tug of War





Installed at Aluminum Company of America's Davenport Works

This 16-Million-Pound Stretcher, largest of its kind, is being used to straighten sheet and plate at *Aluminum Company of America's Davenport works.* The stretcher, operated by Alcoa for the Air Force is part of a $54-million expansion of facilities unveiled recently at the Davenport operations. The mill is now equipped with the biggest sheet and plate rolling facilities in the world.

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wrap being between 90 and 180 degrees. The center roll section 16 is a rotating, tilting, balancing link between end sections 8, which permits greater deflection on one end section than on the other as demanded by unequal belt or strip pressures applied to the roll. The total lateral forces exerted by right hand section 8 and center section 16 will be equal to the total lateral forces exerted by the left hand section 8, so that the belt B will be centered on the roll.

CHARGING OPEN HEARTH FURNACES

△ U. S. 2,818,183, issued Dec. 31, 1957 to Clarence J. Klein, assigned to National Steel Corp., describes an improved charging car for charging material into open hearth furnaces in shorter times.

The charging car includes a large container which can hold many tons of scrap metal and which can be moved into the charging position and its contents, then pushed into the open hearth furnace in a single operation by the operator of the charging machine.

The apparatus is shown in Figures 6 and 7.

STEELMAKING APPARATUS

△ U. S. 2,818,247, issued Dec. 31, 1957 to Charles B. Francis, describes a method and apparatus for converting molten pig iron and scrap to steel, using oxygen and a flux.

The objects of the invention are to provide a process that will be as fast as the bessemer, that will cost less to build and operate per ton of product, that will permit the consumption of more scrap, that will give a greater yield, and that will provide for the use of the several commercial grades of pig iron. A further object is to reduce the amount of fumes formed, and to recover at least 70 per cent of the fumes which are formed. In addition, one-fourth to one-half of the manganese in the charge may be recovered in the steel produced, making the addition of ferromanganese unnecessary except in the case of higher manganese grades of steel.

The converter is shown generally in Figures 8 and 9. It consists of the body B of a tilting open hearth furnace. Instead of checker chambers and flues at opposite ends, scrap-preheating chambers 14 of

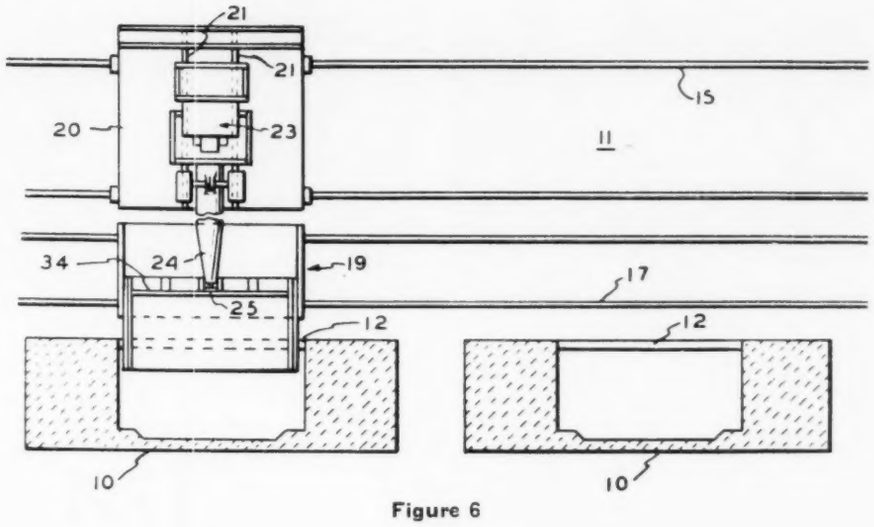


Figure 6

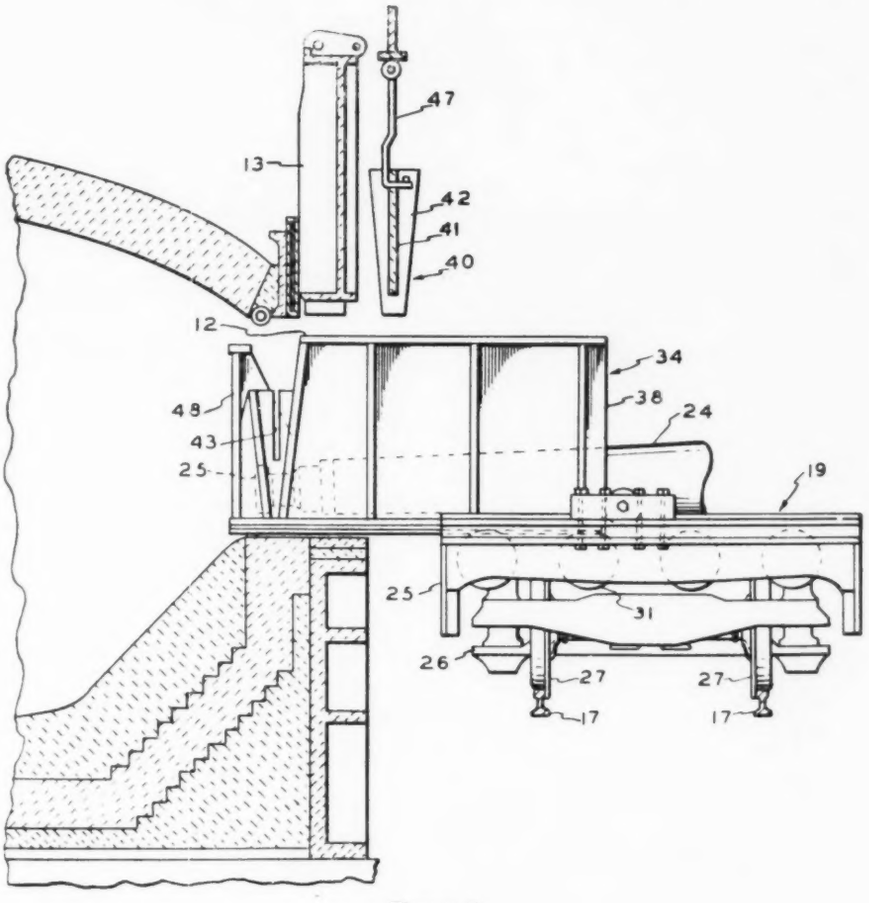
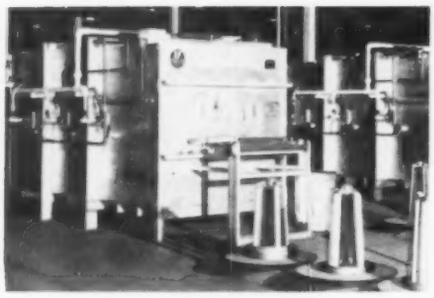


Figure 7

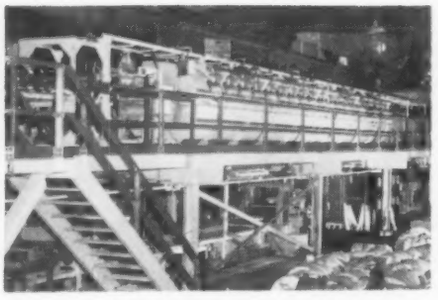
heavy steel plate are provided, having water-cooled frames 90 matching the port rings 9 of the furnace. Each chamber has a rotatable grade 15, to permit charges C of scrap iron and steel to be added to the furnace. Beneath each grate 15, a flue-box 19 leads to a duct 20 and then to a gas cleaner 21. Projecting through the roof of the converter are two oxygen-injecting tubes 23.

As shown in Figure 10, each tube consists of an inner one-inch steel tube 93 closed at its lower end except for a number of $\frac{1}{8}$-in. holes 94. Snugly fitting the tube 93 is a heavy-walled, water-cooled sleeve 25, and near the tip is a refractory snout 33, which prevents the slag from contacting the cold ends of the tube.

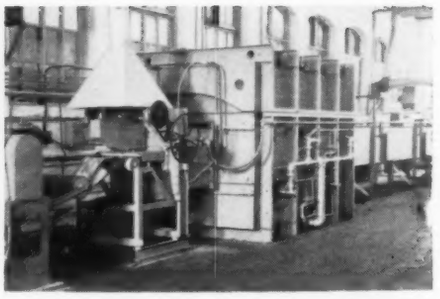
When operation is started for the first time, the refractory body of the converter is heated to a red heat, by means of a fuel gas delivered by burners projected through the doorway 12 and tap-hole 10. Also, the



An EF multiple tube type furnace bright annealing stainless steel wire, continuously. One of an installation of five stainless steel furnaces we built in a prominent steel plant.

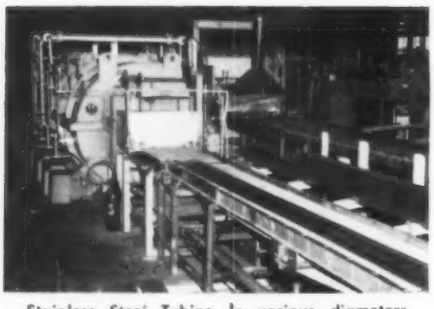


Large capacity EF gas fired furnace bright annealing stainless strip. We build them electrically heated or gas fired for wide or narrow strip, for single or multiple strands.



Stainless steel strip in various widths is bright annealed continuously in this EF gas fired special atmosphere installation equipped with an EF gas fired ammonia dissociator.

Bright Annealing Stainless



Stainless Steel Tubing in various diameters and lengths up to 24 feet is bright annealed continuously in this EF gas fired furnace.

Stainless Steel Strip. Wide, narrow and in various types, is uniformly bright annealed, continuously, in EF furnaces — any tonnage.

Tubing, Strip, Wire, Stampings and Other Stainless Steel Products

Stainless steel strip, wire, heavy and fine tubing, stampings, flatware, cooking ware, drawn and other stainless steel products, in many shapes and forms, are being bright annealed, uniformly, economically, continuously and with laboratory precision in EF furnaces of various sizes and types we have built.

Extensive experience with stainless steel problems, backed by over 40 years of practical furnace building experience and thousands of successful fuel fired and electric installations, enable EF engineers to design and build the best size and type of equipment needed for handling any product or production, or for any heat processing requirement.

Submit your production furnace problems to experienced EF engineers — it pays.

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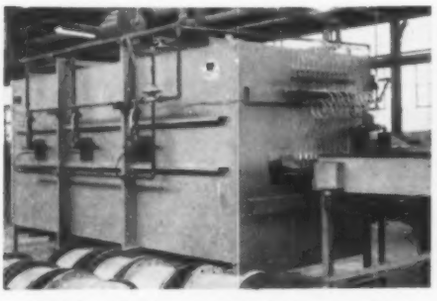
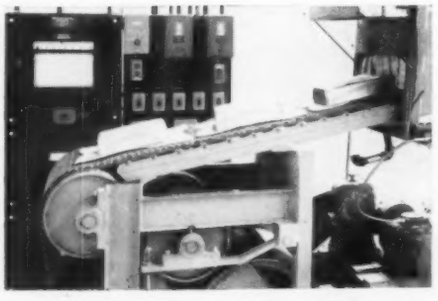
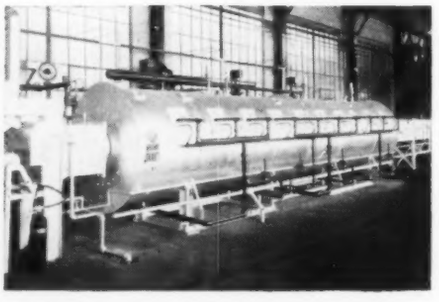


Stainless Steel Wire is bright annealed in this and other EF continuous and batch type gas fired and electric furnaces we build.



Stainless Steel Stampings, flatware, drawn and other products; large, small and in various shapes are bright annealed in EF furnaces



Another type we build for bright annealing stainless strip. This EF furnace also handles other grades requiring lower temperatures.

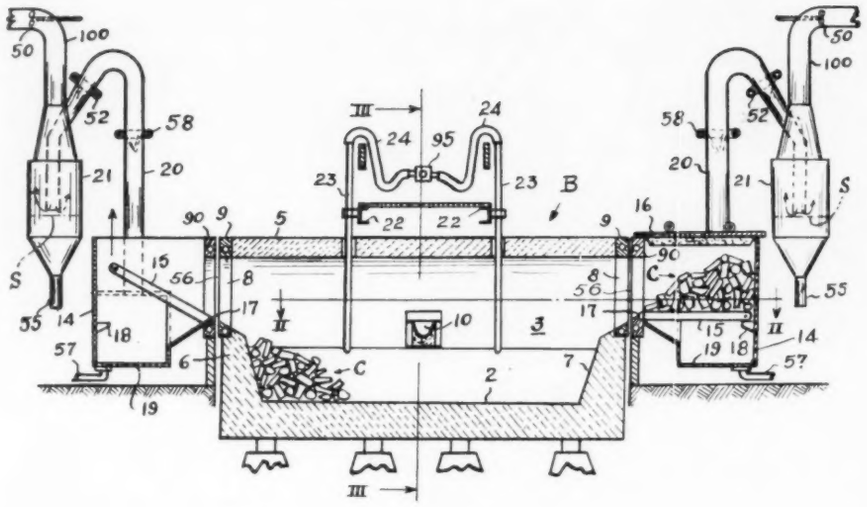


Figure 8

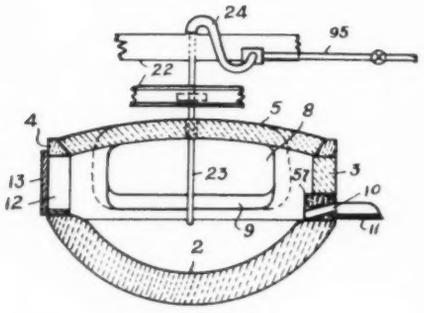


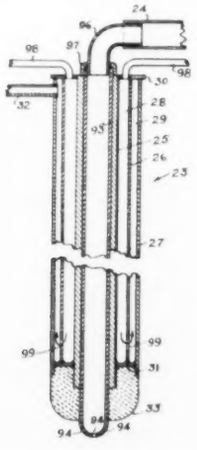
Figure 9

tube assemblies 23 may be temporarily employed as burners.

Either before or during the heating up of the converter, scrap is charged into the chambers 14, by means of an electro magnet carried by an over-head charging crane. When both chambers 14 have been fully charged with scrap C, as indicated in the case of the right-hand chamber 14 in Figure 10, the covers 16 of the chambers are closed upon the tops of the chambers.

When the fuel burners have been lighted, motor-driven fans 50 are set in operation in the stack ducts leading from the gas-cooling and cleaning units 21, and the products of combustion or waste gases are drawn through the ports 8 at the opposite ends of the converter, through the interstices in the scrap charges C and grates 15 and into the flue-boxes 19. The waste gases flow upward through ducts 20 into units 21 and then through flues 100 to a stack or other outlet. During this time jets of cooling water are delivered by sprays 52 into the waste gases flowing into the cleaning units 21.

Figure 10



When the converter body has been heated to desired temperature, the burners are removed from the doorway 12 and tap-hole 10, and the tube assemblies are disconnected from the fuel gas supply and connected to the oxygen supply line 95.

The same crane as was used in charging the scrap C now serves to bring a ladle containing 36 tons of molten pig iron to the converter. The molten metal is poured through a spout inserted through the doorway of the converter, with the oxygen injecting tubes raised as high as possible. Upon the charging of the molten metal into the converter and the removal of the pouring spout, the injecting tubes 23 are lowered to within an inch of the surface of the metal, the door is closed, the oxygen is turned on, and the tubes are lowered until their tips are immersed in the molten iron. After a period of from five to six minutes, about 1500 lb of burned lime (quick lime) is charged in three lots through the doorway to combine with all the oxides of the silicon and phosphorus in the pig iron. At this time the slag layer is about one inch thick and the injecting tubes are lowered to bring the tip below the slag. Ten minutes after all the lime has been added, the slag layer is about two inches thick, and the injecting tube is lowered accordingly, then kept stationary to the finish of the heat.

The first heat is tapped about twenty-five minutes after starting the injection of oxygen. The tapping of the heat is accomplished by tilting the vessel forward and causing the metal to flow out of the spout 11 into a suitable steel ladle.

In the practice of this invention, steel can be produced at a lower cost than any of three processes in common use, and the steel produced by the invention is of as good quality as that produced by the basic open hearth process, since production conditions and the metallurgical reactions are more easily controlled than in the latter process. For example, the apparatus and process of the present invention permits the carbon to be "caught on the way down" with greater accuracy, in view of the fact that at any time after the lime has been added and changed into slag, carbon elimination may be completely stopped by lifting the injection tubes 23 and turning off the oxygen while the bath is sampled and the sample analyzed and/or tested.

METHOD OF OPERATING A BLAST FURNACE

△ U. S. 2,818,329, issued Dec. 31, 1957 to Charles E. Agnew, describes a method of operating a blast furnace so that oxygen enrichment of the air blast may be used advantageously.

An object of the invention is to provide a method of operating a blast furnace producing metallic iron chiefly from iron ores, in which the furnace is continuously burdened with iron bearing materials fluxing materials and carbonaceous solids so that the natural temperature head developed in the lower bosh section of the furnace, in relation to the tapping slag temperature, is insufficient for continuous furnace operation using natural air blast, and then developing the necessary head by increasing heat generation from carbon combustion per unit of air without increasing the volume of the blast entering the tuyeres or substantially increasing gas volume leaving the coke combustion zone.

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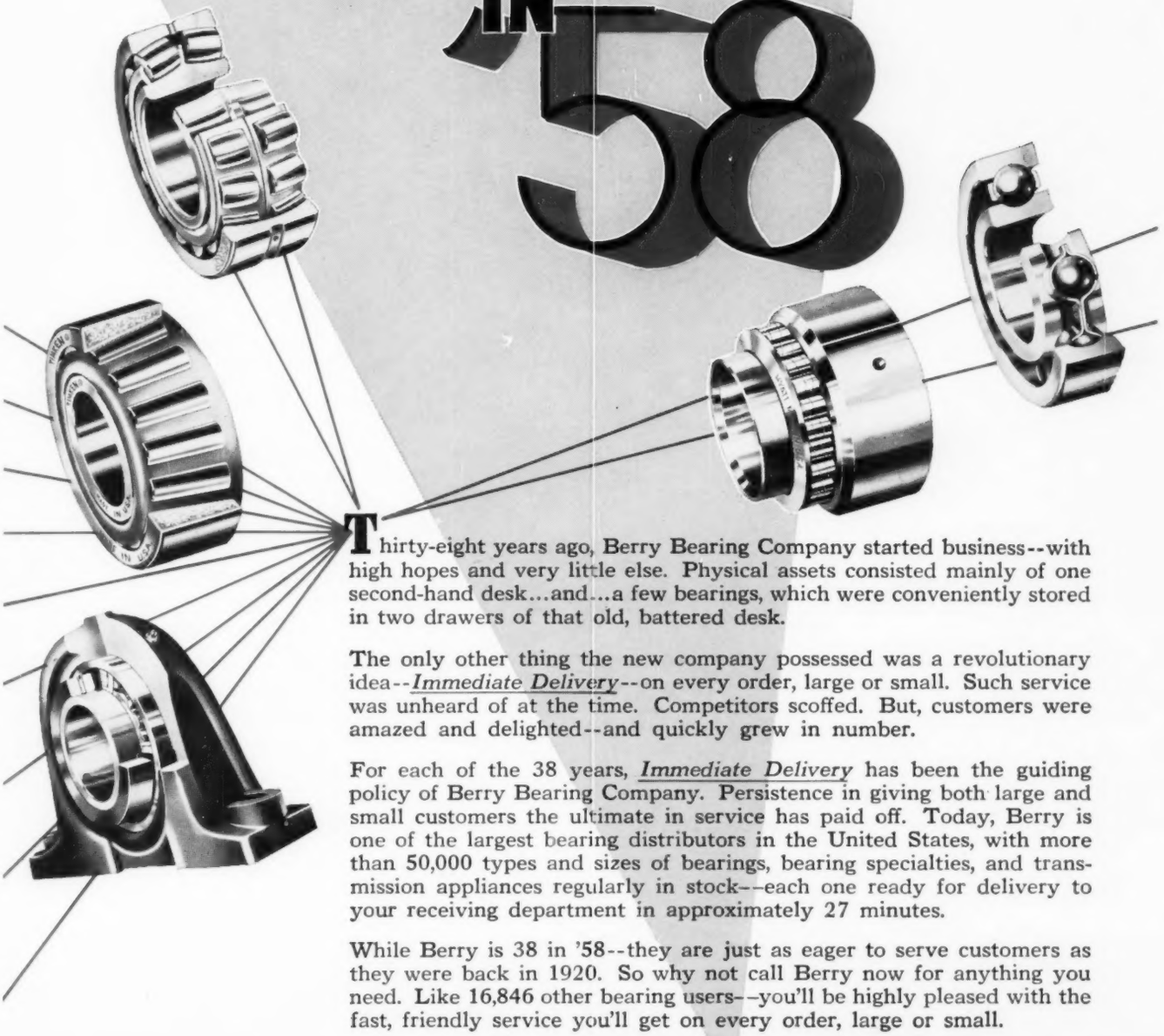

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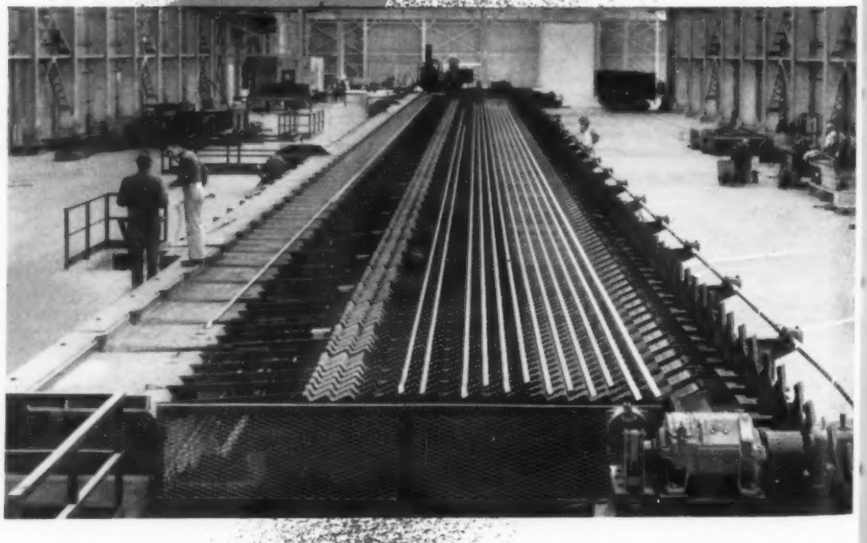

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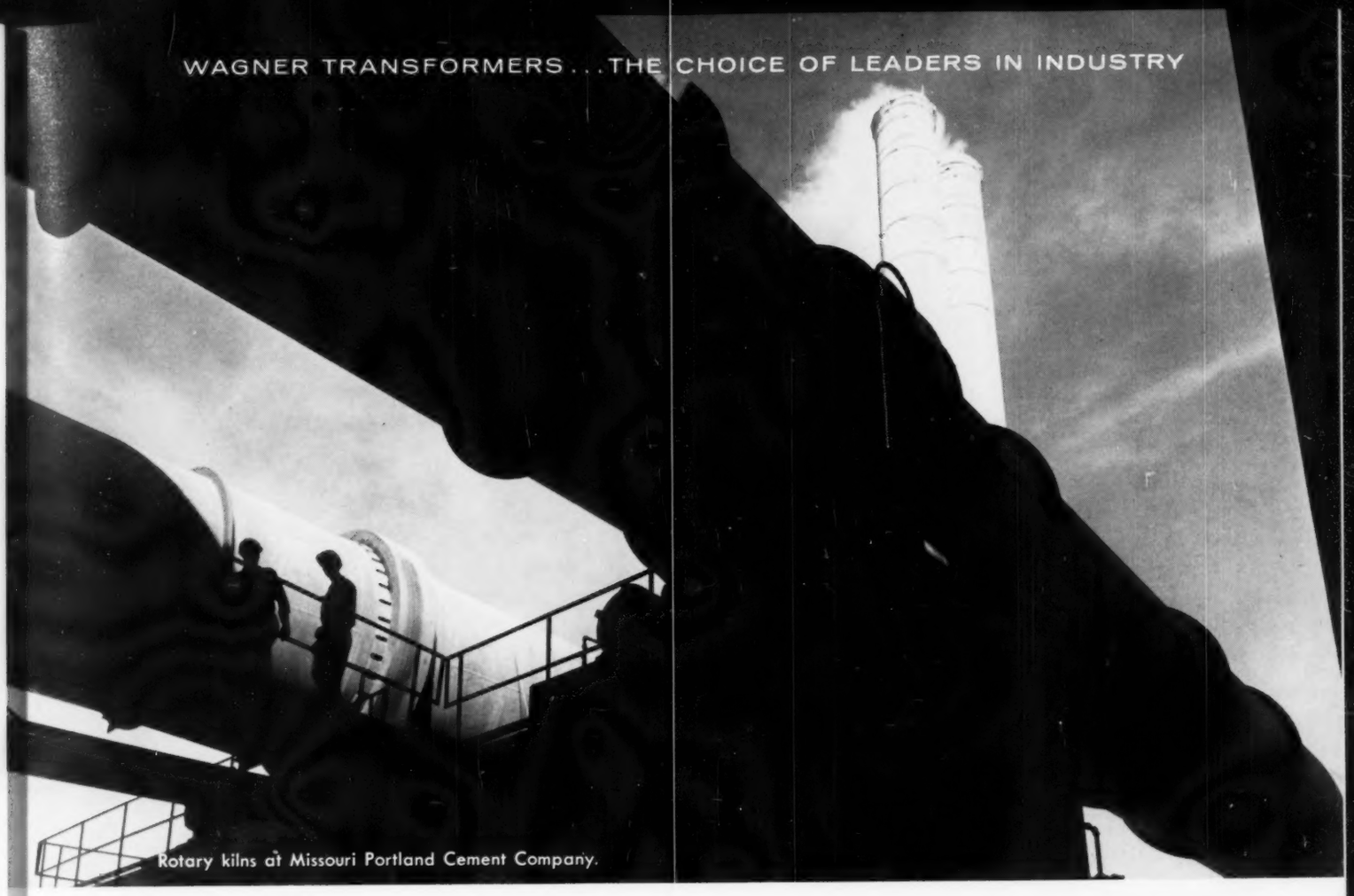

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This pressing need for power was met by the addition of a third 6000/8000 kva Wagner Power Transformer, and by an additional Wagner Unit Substation Transformer for the load-centers.

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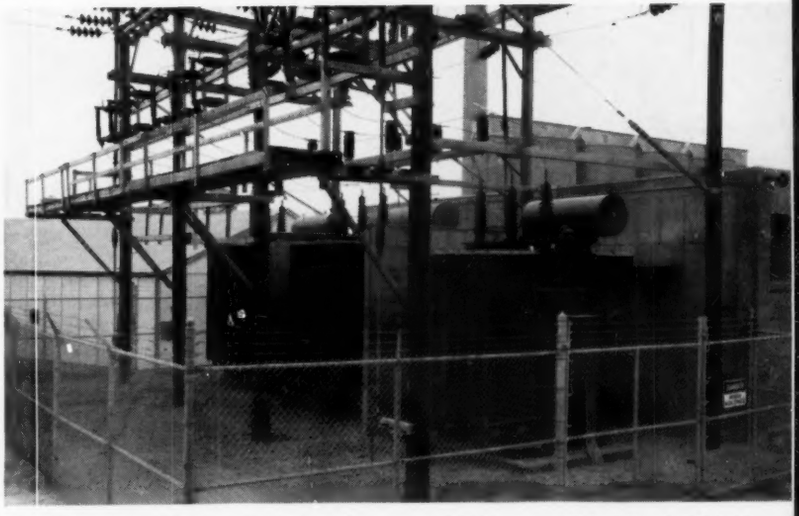

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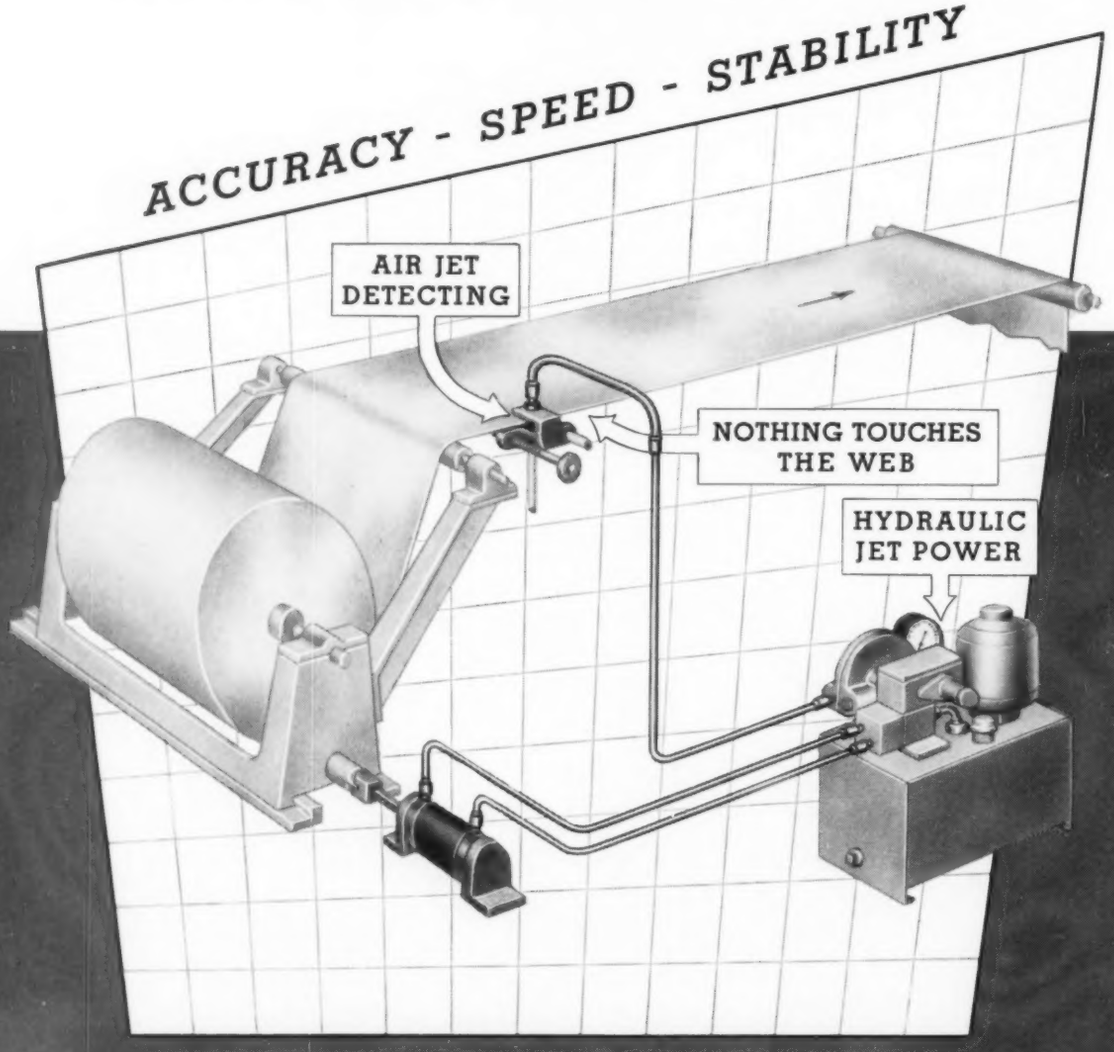
6483 PLYMOUTH AVENUE, ST. LOUIS 14, MO., U.S.A.

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

WEB GUIDE
SIMPLIFIED
by NORTH AMERICAN

ACCURACY - SPEED - STABILITY



Compact light-weight equipment

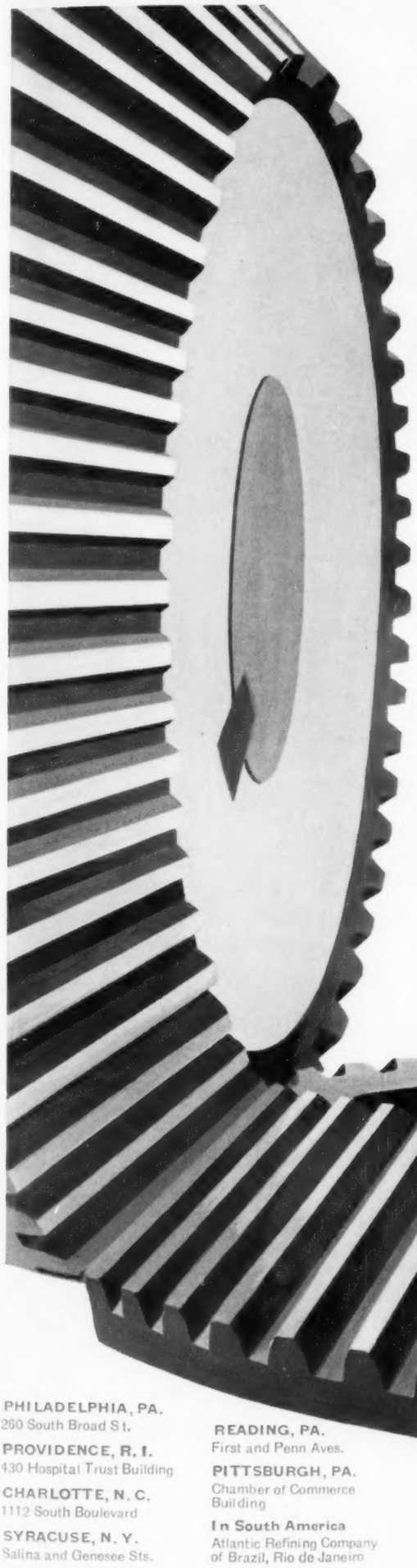
Pressurized return lines allow installation in any convenient position

For engineering information consult your nearby N. A. office or write for Bulletin 2.001

NORTH AMERICAN COMBUSTION
Since 1917

The North American Manufacturing Co.
HYDRAULIC CONTROLS DIVISION
CLEVELAND 5, OHIO

2-001



ATLANTIC LUBRICANTS

for every wheel that turns in industry

Wasting time and profits searching for the right gear oil for your machinery? Atlantic has the key to your problem, because our long experience has made us familiar with your lubricating needs. We've developed the products that can do any lubricating job to perfection . . . at low cost . . . for every wheel that turns in industry.

For further information on Atlantic's family of quality products for industrial lubrication and metal processing, write or wire The Atlantic Refining Company at the nearest office listed below.

ATLANTIC

LUBRICANTS • WAXES
PROCESS PRODUCTS

PHILADELPHIA, PA.
260 South Broad St.

PROVIDENCE, R. I.
430 Hospital Trust Building

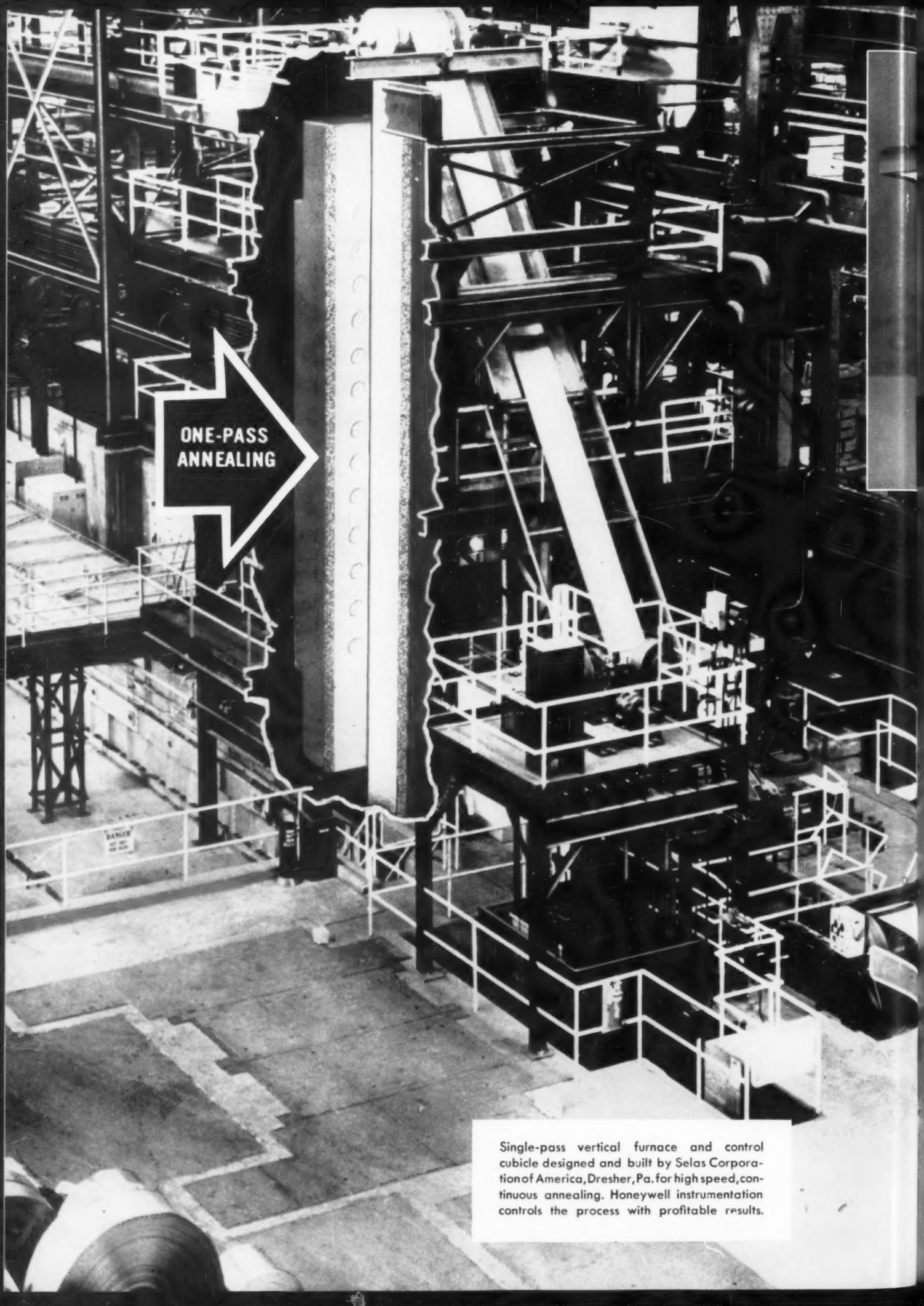
CHARLOTTE, N. C.
1112 South Boulevard

SYRACUSE, N. Y.
Salina and Genesee Sts.

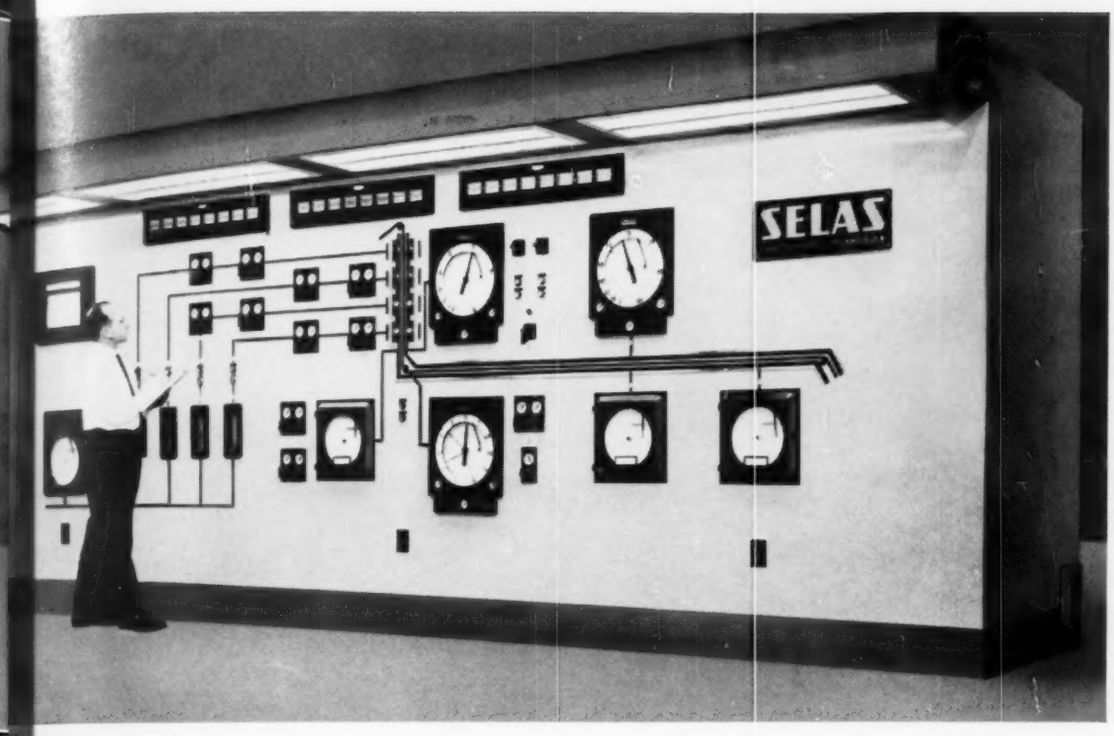
READING, PA.
First and Penn Aves.

PITTSBURGH, PA.
Chamber of Commerce Building

In South America
Atlantic Refining Company of Brazil, Rio de Janeiro



Single-pass vertical furnace and control cubicle designed and built by Selas Corporation of America, Dresher, Pa. for high speed, continuous annealing. Honeywell instrumentation controls the process with profitable results.



Honeywell ***ElectroniK*** Recording Controllers measure sheet temperatures, and line speed, in combination with Honeywell Flow Meter, which records and integrates fuel consumption.

Process Temperature Control

pays off in quality and production in Selas strip annealing line

with Honeywell instrumentation

Steel strip is fully annealed in one pass through a Selas vertical furnace, and delivered continually to the galvanizing bath. In this operation, radiant gas heat is accurately applied across the strip width at temperatures best suited to production of highest quality galvanized steel.

Honeywell instruments, mounted on the graphic panel of a Selas cubicle, provide the fine degree of temperature control required by the process. These instruments control heat input by integrating *strip speed*, *fuel input* and *strip temperature measurements*. Precise heat control speeds the heating process and assures reproducible uniformity, regardless of variations in gauge.

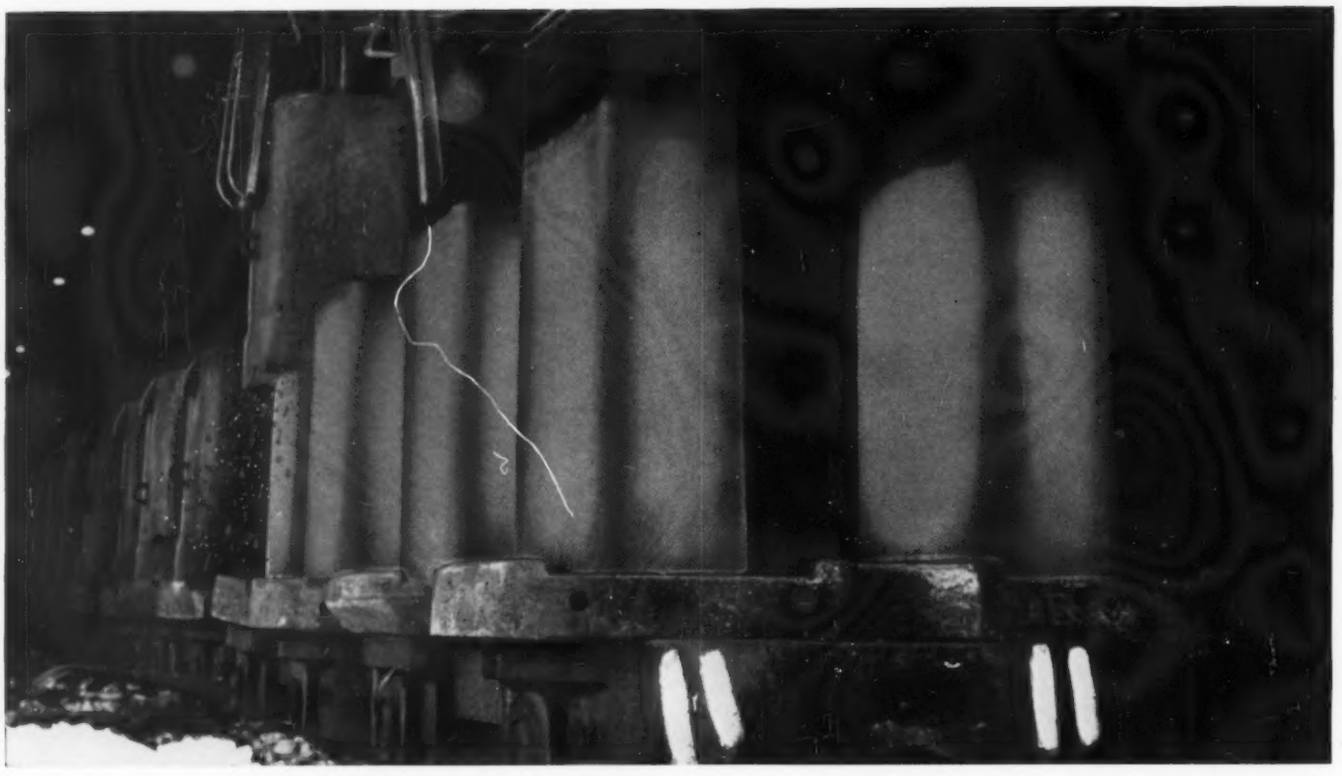
Honeywell instrumentation brings equally profitable results in many steelmaking applications. Your nearby Honeywell field engineer can help you gain its advantages in your own plant. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Honeywell

H HONEYWELL *First in Controls*

How HYATT bearing advantages help produce more steel at lower cost:



ON INGOT CARS—HYATTS TAKE THE SHOCK LOADS OF A STRIPPER 'ROUND-THE-CLOCK!

The shock loads of a stripper pounding a 10-ton ingot free from a mold has little effect on rugged HYATT bearings. In ingot cars like the ones above, HYATT'S straight cylindrical design provides maximum load-carrying capacity with ample reserve for overloads and radical temperature changes. HYATT Hy-Rolls greatly reduce friction and starting power requirements—permit longer trains, faster and smoother car-spotting. For years now, HYATT service-proved advantages have made them the first choice of the steel industry—and constantly-improved quality makes HYATT more than ever your best buy today! It *pays* to standardize on HYATTS! Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.; Pittsburgh; Detroit; Chicago; Oakland, California.

STANDARDIZE ON HYATTS FOR:

MAIN TABLES • RUNOUT TABLES • FURNACE TABLES

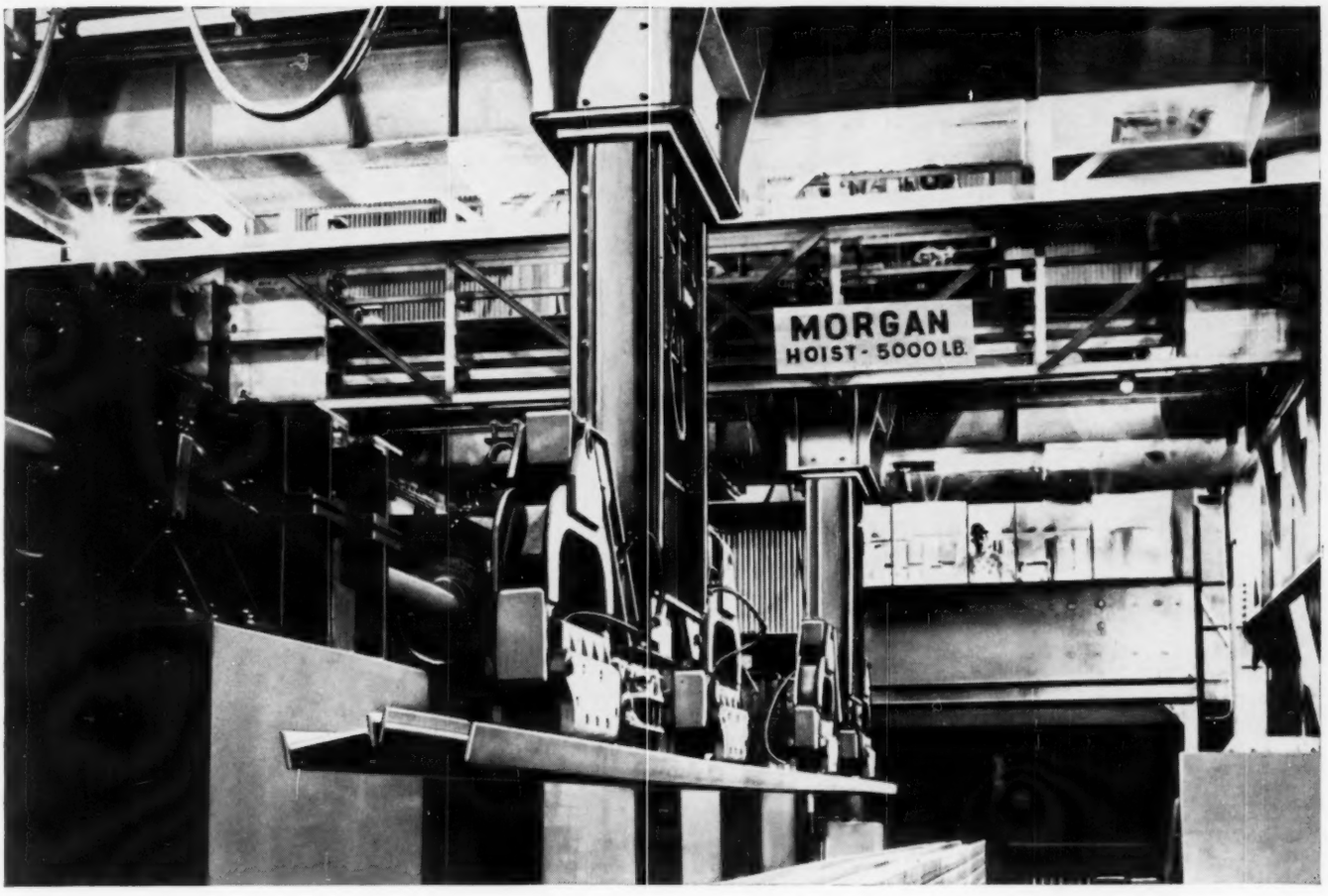
FEED ROLLERS • AUXILIARY ROLLERS • LINESHAFTING

MILL MOTORS • CRANES • CHARGING AND INGOT CARS

THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

1908–1958 GM FORWARD FROM FIFTY

HYATT HY-ROLL BEARINGS FOR STEEL INDUSTRY



Another steel-handling bottleneck broken

. . . by Morgan cranes and mill machinery

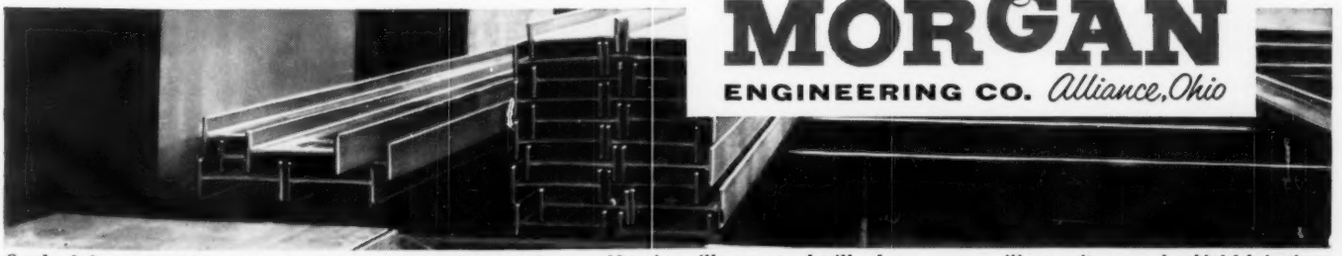
Now beams can be classified and nested with continuous flow production efficiency...and basic components of the system can be profitably applied to handling plates and slabs. Morgan Engineering designed and built the equipment that provides important savings by reducing manual operations and use of a crane withdrawn from normal service.

Beams move from the finishing line on a Morgan roller table and transfer chain assembly. Then they are stacked-to-order on a lower-level platform by the piler cranes.

Two Morgan beam piler cranes, synchronized to work in tandem, handle beams up to 70 feet long ...*one* or *two* at a time. Cranes can also be used singly for handling shorter beams. The lower-level transfer chain platform carries stacked beams to position for movement to shipping or storage areas.

Cost-cutting automation and complete dependability are prime requisites for new steel-handling machinery *of all kinds*. Today's needs are met... and tomorrow's are anticipated . . . in Morgan equipment. Let Morgan Engineering help you reduce *your* production costs by applying our 90 years' experience in designing and building better cranes and mill machinery.

THE
MORGAN
ENGINEERING CO. *Alliance, Ohio*



Overhead electric traveling cranes, gantry cranes, open hearth special cranes, blooming mills, structural mills, shears, saws, auxiliary equipment and welded fabrications.

SAFETY SWITCHES STAND UP UNDER 100,000 AMPERE SHORT CIRCUIT TEST!

INDEPENDENT TESTING LAB RELEASES FINDINGS AFTER GRUELLING "TORTURE RACK" TESTS

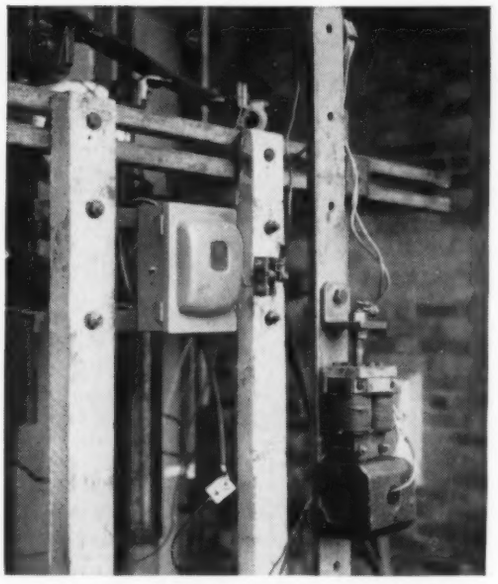
Unprecedented tests have been completed on 30 through 600 ampere rated Square D safety switches equipped with high capacity current limiting fuses. During these tests, switches were closed on a short circuit system delivering up to 100,000 amperes (symmetrical—R.M.S.). In addition, the fault was applied on the closed switches. *All switches withstood the shocks without any sign of failure!*

High Capacity Systems Demand Stamina

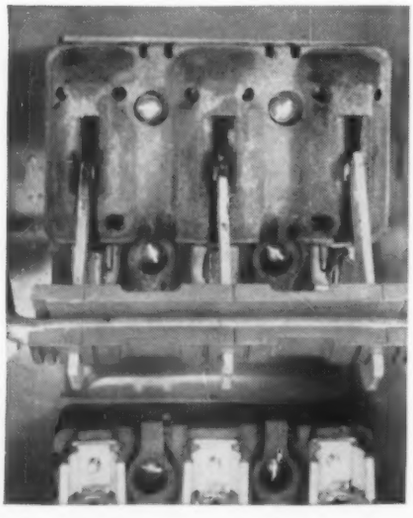
High capacity systems capable of delivering tremendous short circuits are becoming more and more prevalent with the growth of electrical loads. Network systems in metropolitan areas are a source of such faults. Another, the heavy industrial areas, with a concentration of sub-stations and rotating machinery. Terrific stresses and heat generated by such faults are serious hazards to both personnel and equipment unless properly contained. That is why proven protection for switching service and feeder circuits is of major concern.

Square D Standard Switches Do The Job

These tests offer conclusive proof that standard Square D Type HD and Type ND switches, equipped with high capacity current limiting fuses, can be used on such systems without fear of failure. You pay no premium for the proven performance they offer. Why settle for less?



Square D switch on "torture rack" during test involving up to 100,000 ampere short circuit



SUMMARY TABLE • Extract from Report No. S/NA R66—Sheet No. 5

Ampere Rating	Voltage Rating	Catalog Number	Average Symmetrical Prospective Current R.M.S.	Recovery Voltage R.M.S.	Maximum Total Arcing Time	Fuse Type
30	250	A85351	96,600	252	.0009	A2Y-30A
30	250	A85351	96,400	253	.0010	FRN-30A
30	600	A85341	107,000	590	.0020	A6Y-30A
30	600	A85341	106,000	601	.0027	FRS-30A
60	250	A86352	96,400	248	.0010	A2Y-60A
60	250	A86352	95,200	252	.0019	FRN-60A
60	600	A86342	106,000	605	.0011	A6Y-60A
60	600	A86342	108,000	598	.0020	FRS-60A
60	600	A86342	107,000	601	.0013	NAS-60A
100	250	A86353	95,200	253	.0009	A2Y-100A
100	600	A86343	108,000	604	.0014	A6Y-100A
200	250	A86354	95,200	253	.0037	A2Y-200A
200	600	A86344	107,000	602	.0011	A6Y-200A
400	250	A86355	95,900	252	.0039	A2Y-400A
400	600	A86345	106,000	611	.0050	A6Y-400A
600	250	A86356	94,500	251	.0062	A2Y-600A
600	600	A86346	107,000	601	.0062	A6Y-600A

Above • Extract of Nelson High Power Laboratory Report C/NA-66

At left • No sign of failure in this switch interior after 100,000 ampere short circuit test

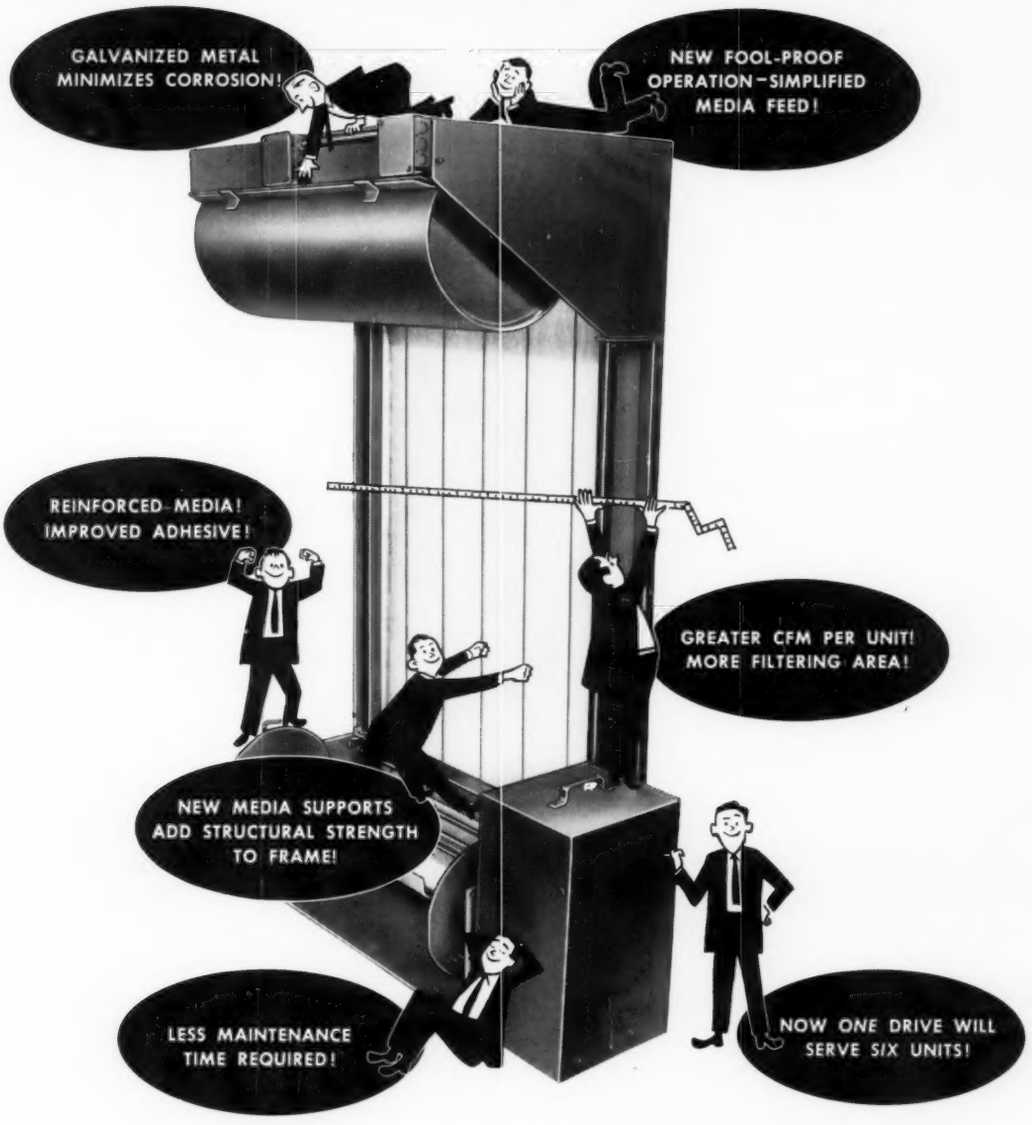
SQUARE D SAFETY SWITCHES GIVE YOU *Certified* PERFORMANCE!

EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

NEW!

AAF model B Roll-O-MATIC air filter

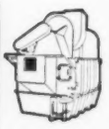

GALVANIZED METAL MINIMIZES CORROSION!
NEW FOOL-PROOF OPERATION–SIMPLIFIED MEDIA FEED!
REINFORCED MEDIA! IMPROVED ADHESIVE!
GREATER CFM PER UNIT! MORE FILTERING AREA!
NEW MEDIA SUPPORTS ADD STRUCTURAL STRENGTH TO FRAME!
LESS MAINTENANCE TIME REQUIRED!
NOW ONE DRIVE WILL SERVE SIX UNITS!

WRITE TODAY FOR NEW ROLL-O-MATIC BULLETIN 248-C!

AAF herman nelson

American Air Filter
COMPANY, INC.
302 Central Avenue, Louisville 8, Kentucky
American Air Filter of Canada, Ltd., Montreal, P. Q.

AAF Filters and Precipitators



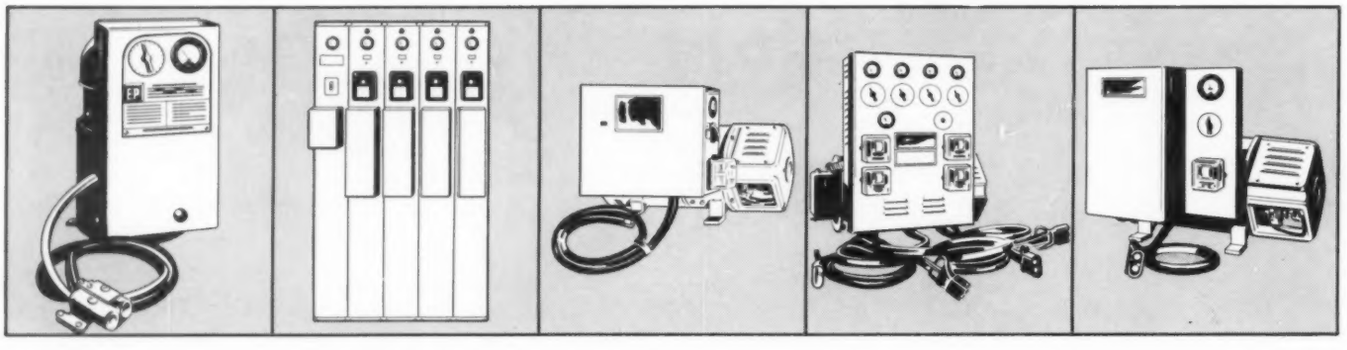
AAF Dust Control Equipment

— BETTER AIR IS OUR BUSINESS —

Herman Nelson Unit Heaters

Illinois Heating Specialties

EXIDE TO MARKET ALL ELECTRIC PRODUCTS CO. CHARGERS



First battery manufacturer to offer complete line of chargers for all industrial uses

Here's another reason to buy from Exide. You can now get a complete power package—battery and charger—from one source. Exide assumes total responsibility for all sales and service of both batteries and chargers.

This additional advantage in buying from Exide results from an agreement with Electric Products Co., Cleveland, Ohio . . . world's most experienced manufacturer of battery chargers. Exide now exclusively handles EP's entire line of chargers for all industrial applications. They are available from the same people who handle Exide industrial batteries—from the same 42 Exide sales and service offices in key cities coast to coast. This means close, efficient and competent service for all users of Electric Products chargers, old and new. Trade practices of Electric Products Co. will be continued.

Electric Products Co., first to develop many types of automatic chargers, makes a complete line of chargers for all industrial applications . . . industrial truck, switchgear, telephone, marine, mining, railroad. Models include fully automatic motor-generator and diverter pole equipment, plus selenium and silicon rectifiers. For years, Electric Products Co. has worked closely with Exide engineers in pursuit of its continuing research program.

Write for complete technical details and prices. Exide Industrial Division, The Electric Storage Battery Company, Philadelphia 2, Pa.

Exide®

These air or steam operated

CINDER CARS

can be dumped to either side

automatically

Where required, Treadwell air or steam operated cinder cars can be furnished for dumping to either side of the track. No change in mechanism is required; direction can be reversed automatically.

The dumping mechanism consists of a steel cylinder, mounted on guide rods between two steel pedestals. Movement of the cylinder rotates the pot, emptying the contents.

By the use of wrist pins in the end of the bail, greatly increased leverage is obtained. This permits the use of smaller, less expensive cylinders without increase in steam or air pressure.

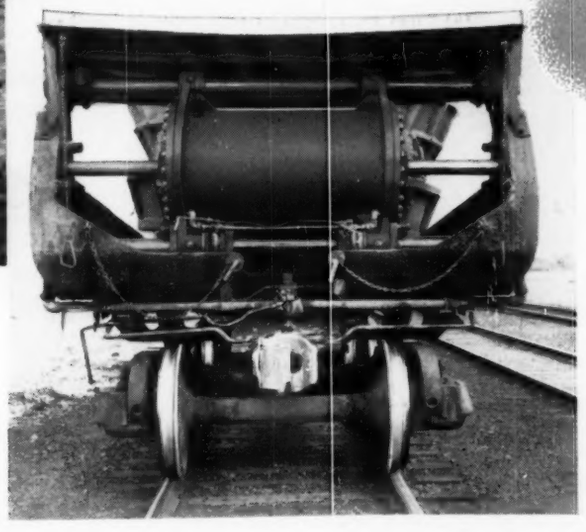
Treadwell cars can be built to carry from one to four pots. They can also be supplied with electric dumping device, or can be arranged for dumping by crane.

Send for new 12-page bulletin which describes these cars in detail. Ask for a copy of bulletin 61.

M. H. TREADWELL COMPANY, INC.
140 Cedar Street, New York 6, N. Y.
1015 Farmers Bank Bldg., Pittsburgh 22, Pa.
208 So. LaSalle Street, Chicago 4, Ill.

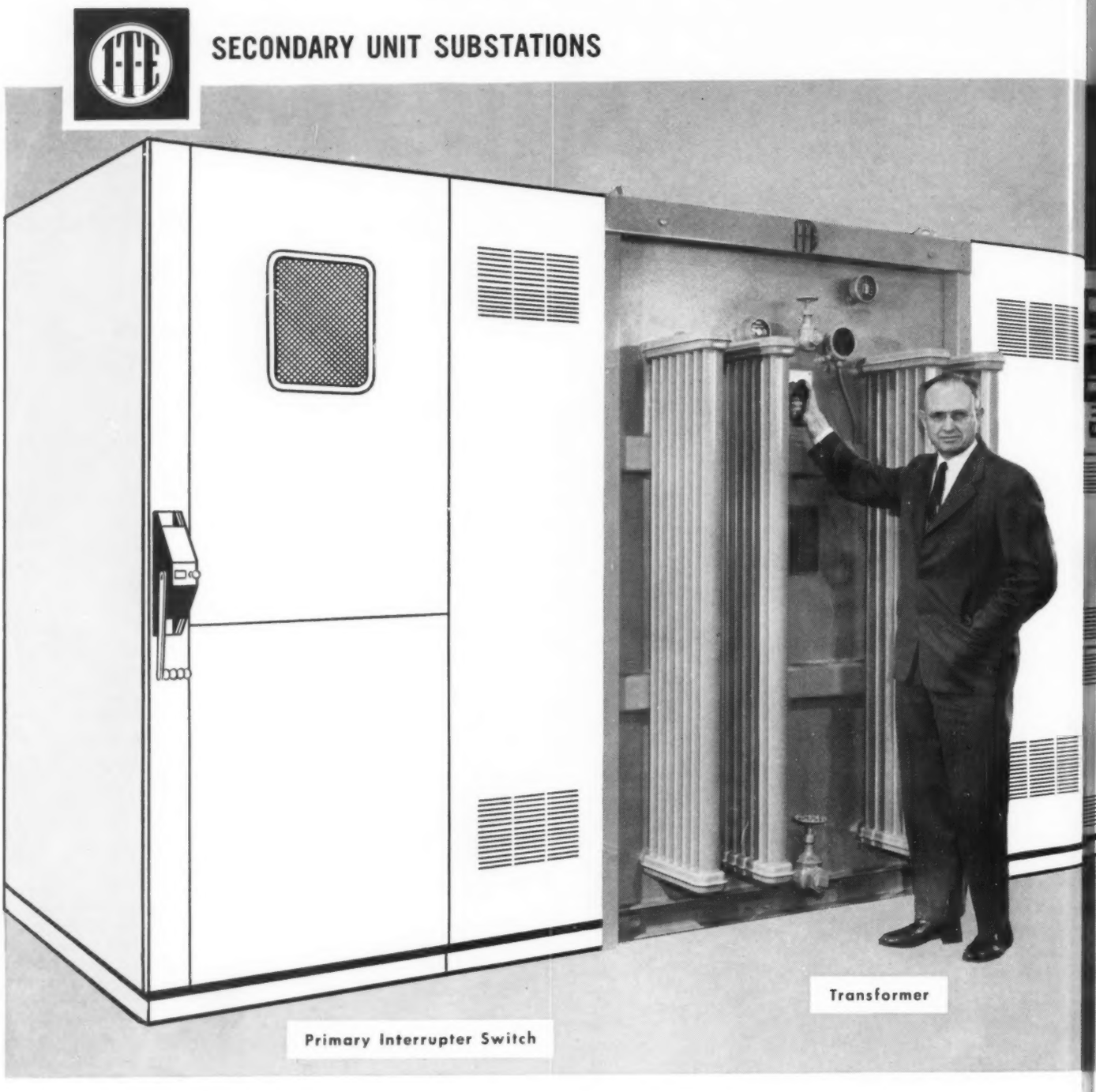
TREADWELL

CINDER CARS



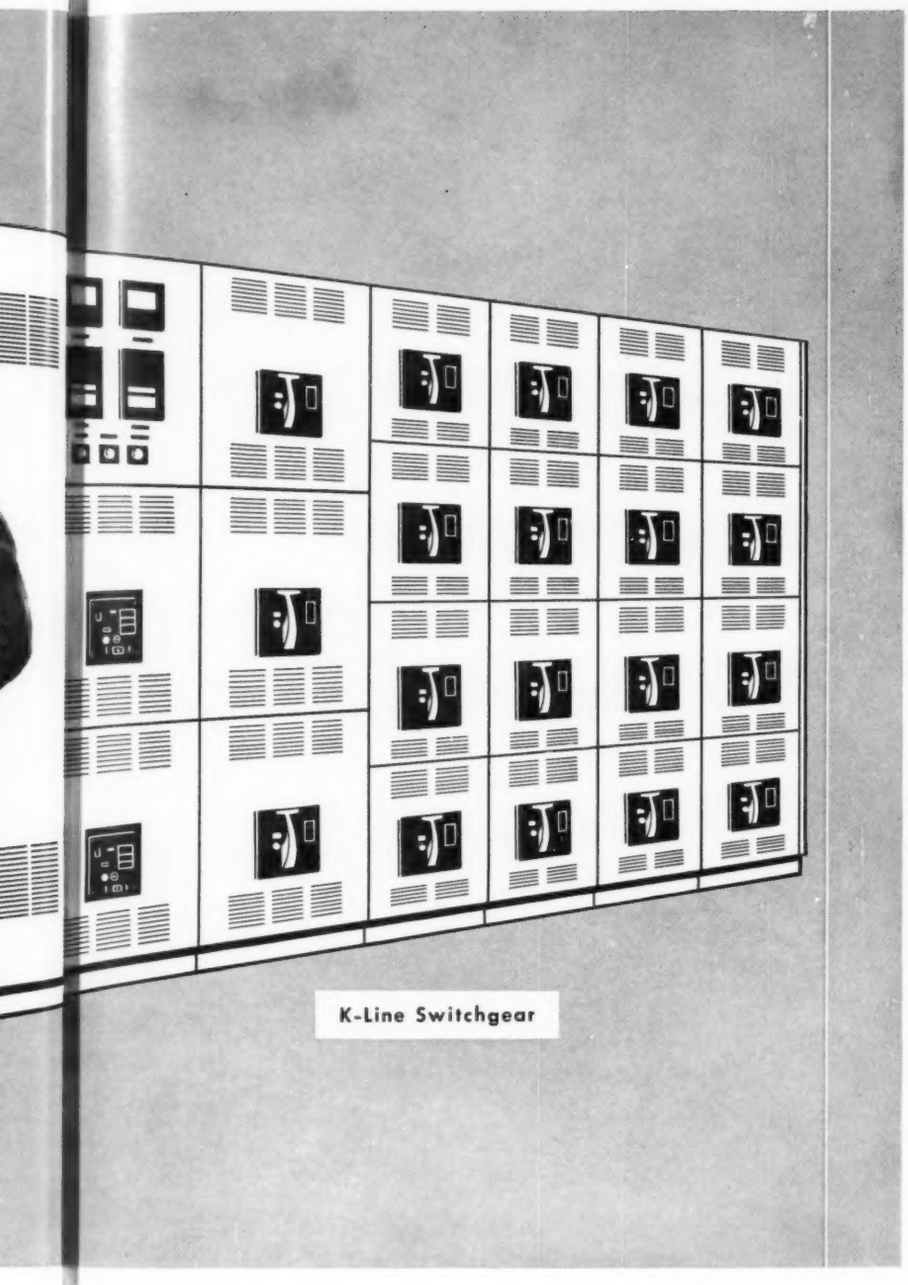
Car with air dumping device, designed for dumping to either side of track. Cylinder may be either cast or rolled steel.

TR-14



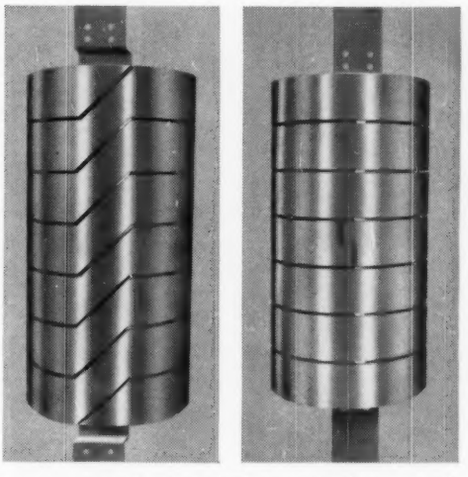
TRANSFORMERS BUILT ON FRESH IDEAS

New designs, incorporating latest ideas, insure more dependable performance, better looking units



K-Line Switchgear

Coils stay put. Double jackscrews in combination with tie rods between upper and lower core clamps hold coils rigidly in place, even under severest short circuit stress.



Brute strength secondaries. A fresh approach to high current secondaries for dry type transformers is this coil formed from solid copper bus. This unique design embodies great structural strength, and high conductivity.

Look what I-T-E gives you now in unit substations: transformers designed fresh from the ground up . . . incorporating developments based on the most up-to-the-minute transformer technology.

This fresh approach to transformer design and construction has produced remarkable new gains in transformer performance: greater dependability, stronger construction, more effective use of materials.

Only I-T-E offers you unit substations completely engineered and built in a single plant . . . insuring coordinated engineering, easier ordering, simultaneous delivery of all elements, simpler installation, and a single, dependable name in back of them. Write for complete details. Switchgear Division, I-T-E Circuit Breaker Company, 19th & Hamilton Sts., Philadelphia 30, Pa. In Canada: Eastern Power Devices Ltd., Port Credit, Ont.

I-T-E CIRCUIT BREAKER COMPANY

PHILADELPHIA, PENNSYLVANIA

BUILT BIG . . . TO CLEAN BIG

Giant Pangborn unit Rotoblasts loads up to 12,000 lbs. in minutes!

A side view of the 72 cu. ft. Pangborn Rotoblast Barrel. Pangborn Barrels available in 1½, 3, 6, 12, 18, 20, 32, 72 and 102 cubic foot sizes

How do you build a giant blast cleaning barrel? If you're Pangborn, you use steel, inches thick. You put in the heaviest apron conveyor ever made. You incorporate the patented abrasive separator, abrasive-tight door, simplified Pangborn construction. You power it with two Rotoblast wheels that hurl *60 tons of abrasive an hour.*

Sure, it's tough to build . . . but it's worth it when you come up with a 72 cu. ft. Pangborn Rotoblast® Barrel! This unit cleans 6-ton loads *in five minutes* and gives the lowest operating and maintenance costs in the blast cleaning field! It's one of many Pangborn Rotoblast Machines. There's one for *your* problem.

The Pangborn Engineer in your area will be glad to take off his coat and go to work on your cleaning problem at no obligation. And for complete information on Rotoblast Barrels, write to: Pangborn Corp., *4400 Pangborn Blvd., Hagerstown, Md. Manufacturers of Blast Cleaning & Dust Control Equipment.*

Clean it fast with Pangborn ROTOBLAST®

This man is tabling downtime indefinitely with SKF's new steel pillow blocks

He's cutting bearing maintenance to a minimum yet drastically reducing the chances of table downtime! For he's equipping the mill tables with SKF's new SMT Steel Pillow Blocks with self-aligning spherical roller bearings.

The split construction design of these new pillow blocks makes it possible for rolls to be removed without disturbing base alignment. The non-rubbing, labyrinth-type seal effectively keeps out scale and water and is not affected by high temperatures.

The Type "C" Spherical Roller Bearing gives him the highest capacity available in any self-aligning roller bearing. This high capacity is available despite angular misalignment caused by heat warpage of the table structure or other factors promoting table misalignment.

He'll save with direct, center lubrication, too . . . because a lubricating groove is provided around the circumference of the outer ring of SKF sphericals with equally spaced holes drilled in the ring connecting the groove to the center of the bearing. Grease moves around the groove and through the holes which channel it directly to the center of the bearing.

Why not make the change-over to SKF Steel Pillow Blocks yourself? Write for Catalog #447.

7821

Spherical, Cylindrical, Ball, and Tyson Tapered Roller Bearings

EVERY TYPE—EVERY USE

SKF®

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

® REG. U. S. PAT. OFF.

PROOF: Shaw-Box can build cranes to your specs (or AISE)

Every steel mill has its own special materials handling problems. Problems which could be handled by standard crane designs 30 years ago now demand cranes built to specifications unique to a single mill.

These ten leading steel companies developed their own crane specifications (or chose modern AISE standards.) Each awarded the job of constructing the crane to Shaw-Box.

REASON: Shaw-Box can produce *any* type of crane of *any* capacity. We are not bound by traditional concepts of design. Usually, we can offer better delivery. Control of Shaw-Box Cranes is a miracle of precision and speed.

When your company next prepares specifications for a crane — of any type — make sure they are sent to Shaw-Box.

58K-1

"Shaw-Box"® CRANES

MANNING, MAXWELL & MOORE, INC.
SHAW-BOX CRANE & HOIST DIVISION
388 West Broadway • Muskegon, Michigan

Builders of "SHAW-BOX" and 'LOAD LIFTER' Cranes, 'BUDGIT' and 'LOAD LIFTER' Hoists and other lifting specialties. Other Divisions produce 'ASHCROFT' Gauges, 'HANCOCK' Valves, 'CONSOLIDATED' Safety and Relief Valves, 'AMERICAN' and 'AMERICAN-MICROSEN' Industrial Instruments.

In Canada: *Manning, Maxwell & Moore of Canada, Ltd., Avenue Road, Galt, Ontario.*

single stand reversing plate mill

BLAW-KNOX PLATE MILLS

Blaw-Knox designs and builds a full range of continuous or single stand reversing plate mills for rolling ferrous and non-ferrous slabs. Other Blaw-Knox equipment for the metals industry includes complete rolling mill installations including all auxiliary equipment for ferrous and non-ferrous metals, iron, alloy iron, and steel rolls, Medart cold finishing equipment, carbon and alloy steel castings, fabricated steel plate or cast-weld design weldments, steel plant equipment, and heat and corrosion resisting alloy castings.

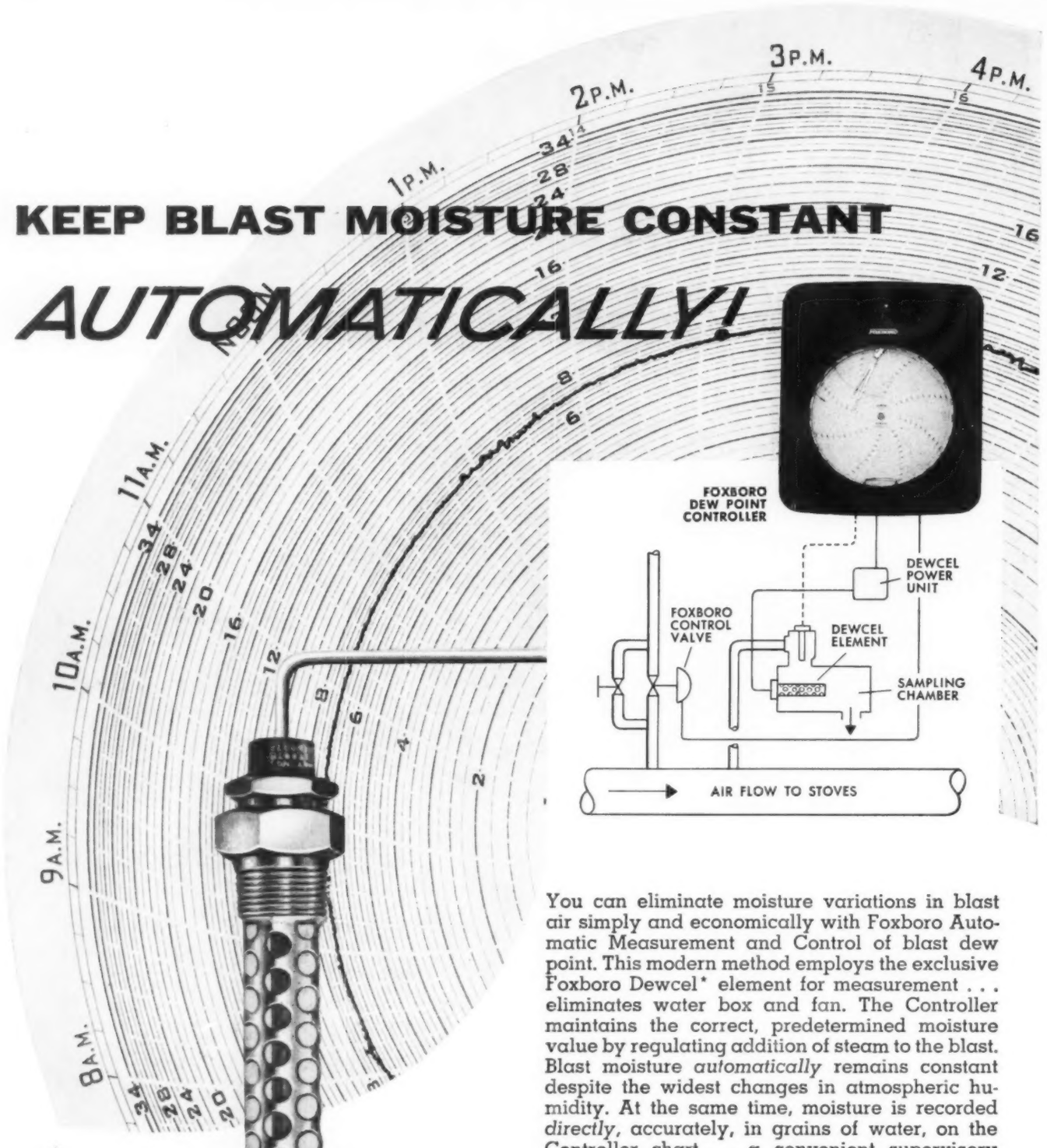
BLAW-KNOX

BLAW-KNOX COMPANY

Foundry and Mill Machinery Division
Blaw-Knox Building · 300 Sixth Avenue
Pittsburgh 22, Pennsylvania

KEEP BLAST MOISTURE CONSTANT

AUTOMATICALLY!



▲ Section of Foxboro Dew Point Controller Chart showing typical moisture control record from actual installation. Control action automatically balances changes in atmospheric humidity.

◀ The Foxboro Dewcel element is a highly accurate, rugged, moisture-sensing element designed for industrial use. It requires no water box — practically never needs attention.

You can eliminate moisture variations in blast air simply and economically with Foxboro Automatic Measurement and Control of blast dew point. This modern method employs the exclusive Foxboro Dewcel* element for measurement . . . eliminates water box and fan. The Controller maintains the correct, predetermined moisture value by regulating addition of steam to the blast. Blast moisture *automatically* remains constant despite the widest changes in atmospheric humidity. At the same time, moisture is recorded *directly*, accurately, in grains of water, on the Controller chart . . . a convenient supervisory record.

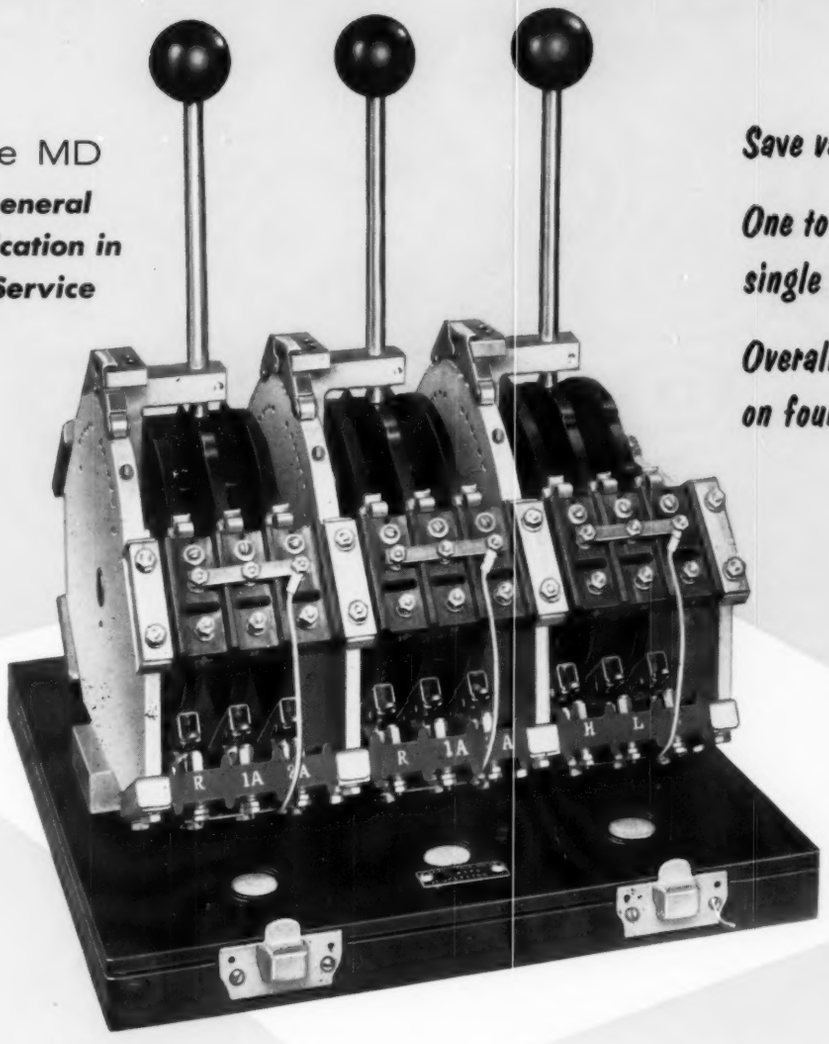
Foxboro Automatic Measurement and Control of blast dew point has already proved its value in over 50 installations through more stable furnace operation . . . better control of iron quality and uniformity. For full details, write for AED Sheet 330-1 and Bulletin 11-11A. And, if you wish, a Foxboro Engineer will call to make recommendations for *your* furnace. **The Foxboro Company, 585 Neponset Ave., Foxboro, Mass., U.S.A.**

FOXBORO

REG. U. S. PAT OFF

AUTOMATIC CONTROL OF BLAST DEW POINT

Type MD
for general application in Mill Service



Save valuable mounting space

One to four switches in a single enclosure

Overall length less than 22" on four unit switch

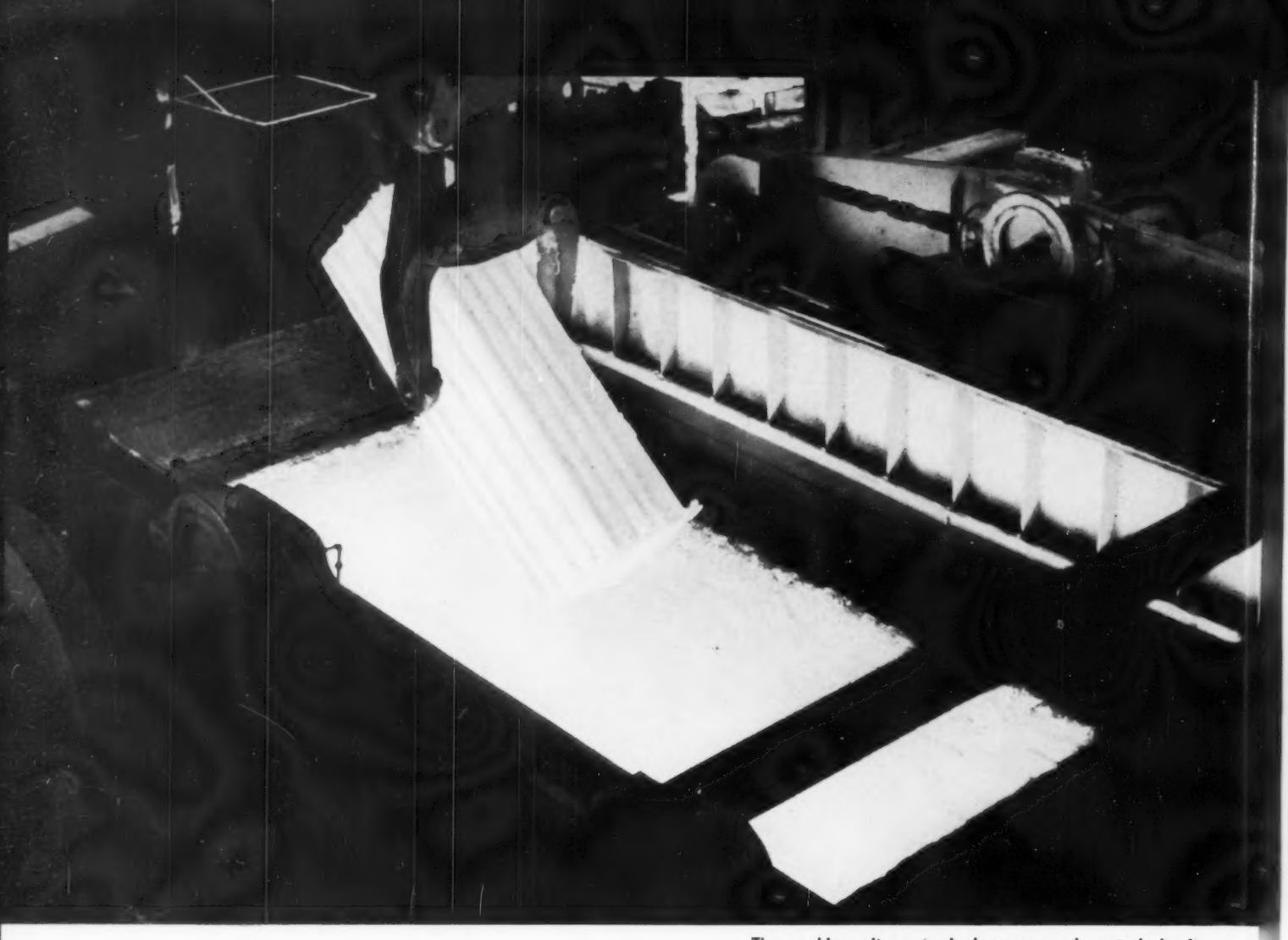
P-G master switches

Unique in design, the Post-Glover Type MD Master Switch saves valuable mounting space in crowded crane cabs or mill pulpits where sufficient room has always been a problem. Each single Master has a maximum of 12 circuits and up to 6 points either direction. The operating lever has exceptionally short angular travel and can easily be adjusted in length, thus adding to operator comfort and efficiency.

Enclosure easily removed.

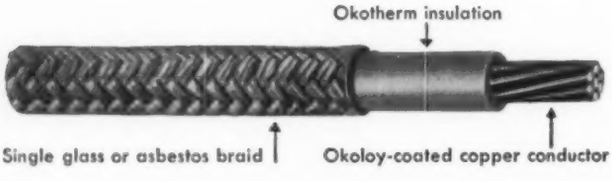
Write for Bulletin 410

THE **POST-GLOVER** ELECTRIC COMPANY
Established 1892
Office and Factory—KENTON LANDS ROAD, ERLANGER, KENTUCKY
Mailing Address—BOX 709, COVINGTON, KENTUCKY



The soaking pit—a typical power and control circuit application for Okotherm-insulated wires and cables.

OKOTHERM . . . a service-proved electrical insulation for high ambient temperatures



Used on overhead cranes in open hearth rooms and around soaking pits, as power feeders, motor, control, and lighting circuits, wherever high temperatures are routine, Okotherm-insulated cables have set amazing records for service life.

Why? They offer all the characteristics essential for dependable circuit operations in these high temperature locations. Extraordinary heat resistance . . . high temperature compressive strength . . . all-temperature flexibility . . . resistance to ozone . . . high dielectric strength—all these mean greater reliability, longer service in locations too hot for other cable constructions.

Okotherm is a thermosetting insulation compounded of silicone rubber. It is an almost entirely inorganic, Class H insulation that may be used for continuous operation at 150C (as high as 200C under certain conditions).

Okotherm-insulated wires and cables are available with a protective covering of glass, asbestos, orlon or nylon braid; and if required, a seamless aluminum sheath overall. For complete details contact your local Okonite Representative . . . or write for Bulletins IS-2117 and IS-1088. The Okonite Company, Passaic, New Jersey.

4902

where there's electrical power . . . there's **OKONITE CABLE**

New

Link-Type HINGE ALIGNMENT DEVICE

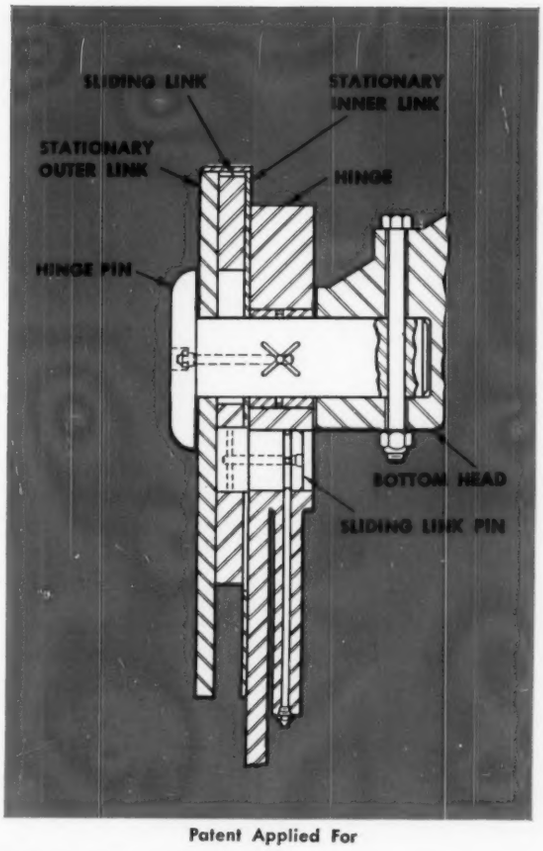
available on Mead-Morrison Grab Buckets

...eliminates hinge gears

When non-crushable material gets caught in a conventional grab bucket gear-type alignment device, it means trouble . . . jammed and broken teeth.

The exclusive link-type hinge alignment device developed by Mead-Morrison *eliminates* this trouble. It operates by the interaction of a linkage of steel plates instead of the vulnerable gear teeth of conventional alignment devices. The mechanism is fabricated entirely of high tensile alloy steel. In addition, it has a much larger bearing surface than the ordinary gear-tooth construction, is entirely enclosed and easily lubricated. The result . . . less lubrication problem . . . less maintenance expense.

Write for free working model of this device.



Patent Applied For

MEAD-MORRISON

Division of McKIERNAN-TERRY CORPORATION

HARRISON, NEW JERSEY

MK823

BLAST FURNACE PROGRESS

demands superior refractories

Harbison-Walker Linings have set many world's records

Harbison-Walker has furnished more than half the blast furnace refractories used in North America—and many world's records have been made with Harbison-Walker linings. These outstanding records are due to the most modern and efficient manufacturing facilities, the full complement of types and classes, and the carefully controlled high quality of the products.

Through continuous product research and engineering development, Harbison-Walker has provided new and improved refractories to meet the iron and steel maker's increasing demands. Today Harbison-Walker brands include the types and classes that will serve best for these requirements.

OUTSTANDING HARBISON-WALKER BLAST FURNACE REFRACTORIES

- **BENEZET BF (Penna.)**
- **H-W ALA BF (Alabama)**
- **H-W MO BF (Missouri)**
- **H-W KY BF (Kentucky)**

These high duty fireclay brands of highest quality possess the combination of desirable properties which make them especially suited for complete linings, including hearth and bosh, inwall and top zones.

• **H-W 18**—H-W 18, in many instances, is used to advantage for complete linings. It is highly refractory and resistant to disintegration by carbon monoxide. Other properties which make it especially adapted for blast furnace linings are low permeability and porosity, and excellent high-temperature volume stability. High mechanical strength accounts for its great resistance to impact and abrasion. H-W 18 blast furnace linings are manufactured in Pennsylvania and Kentucky from clays long regarded as standards for this application.

• **VARNON BF**—This brand is an extremely hard-burned, super-duty fireclay brick which represents the ultimate in alumina-silica refractories for blast furnace linings. Its important properties are exceptional volume stability and resistance to abrasion at high temperatures; low porosity and permeability; immunity to disintegration in carbon monoxide atmospheres; high refractoriness; and resistance to slagging.

These Harbison-Walker blast furnace brands excel in workmanship and accuracy of dimensions which makes possible the tightest bricklaying construction.

H-W MORTARS

Among leading Harbison-Walker cold-setting bonding mortars for the iron and steel industry, HARWACO BOND is the most widely used for laying blast furnace and stove linings.

H-W SILLIMANITE, a hot-setting bonding mortar is particularly suited for laying bottom blocks and for use in the other high temperature zones of blast furnace linings.

H-W BLAST FURNACE STOVE BRICK

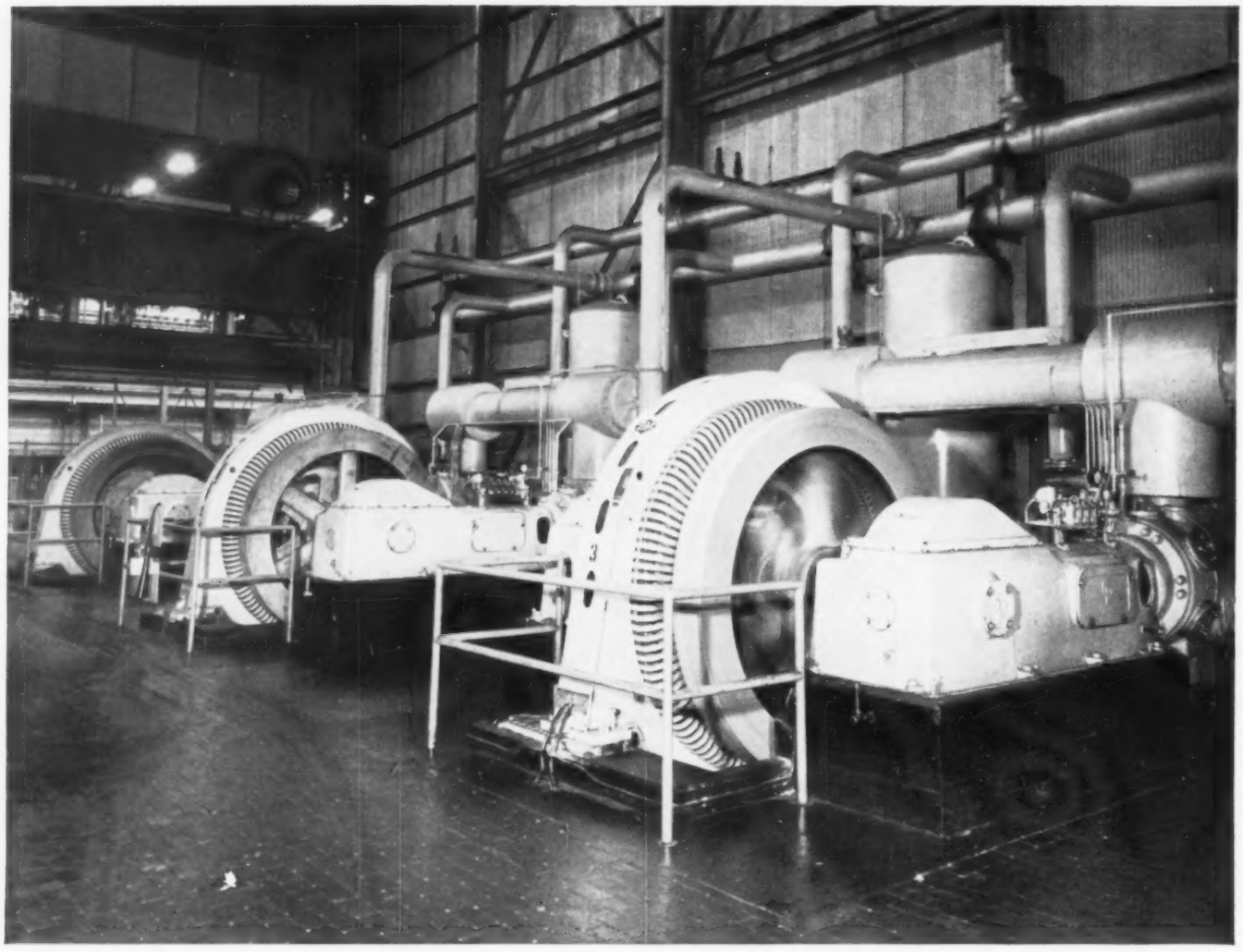
Harbison-Walker stove brick satisfactorily fulfill the most severe requirements for domes, walls, combustion chambers and checkers. These include various brands of high duty and super-duty fireclay brick as well as several brands of high-alumina refractories.

KAOSIL is a semi-silica fireclay brick which is unique in that it possesses unusual properties which are especially beneficial for blast furnace stove requirements. It remains rigid under appreciable load at high temperatures, and in atmospheres containing volatile alkalies it develops a thin glaze which greatly retards penetration. Used in combustion chamber walls and domes, KAOSIL prolongs refractory life in these vulnerable positions.

HARBISON-WALKER REFRACTORIES COMPANY
AND SUBSIDIARIES

World's Most Complete Refractories Service

GENERAL OFFICES • PITTSBURGH 22, PA.



Above are three 500 hp, 225 rpm, 2300 volt, 0.8 power factor E-M Synchronous Motors driving air compressors in the tin finishing department at the new Fairless Works of United States Steel Corporation. Three other 500 hp and five 300 hp E-M Motors also drive air compressors, in the hot strip and slab mill, central power station, open hearth pumphouse and sulfate building of the coke works.

Power costs held low on compressor drives at new Fairless Works

Supplying air for controls, tools, handling systems and maintenance equipment is vital business at Fairless Works. And cost of power for operation of the air compressors is an item to be watched in such a large mill.

That's exactly where the E-M Synchronous Motors fit in. They help contribute real economy and rugged reliability to compressor operation.

First of all, these 11 E-M Motors are capable of supplying approximately 2700 reactive kva to improve plant power factor, a significant element when you want to minimize power costs.

Secondly, the inherent high efficiency of E-M Synchronous Motors utilizes power most sparingly.

Other economies are accomplished by use of simple and low-cost full-voltage control for across-the-line starting. Maintenance economy is foretold by simplicity of E-M Synchronous Motor direct-connection . . . by extra strong lashing of E-M stator coils . . . by the high capacity of E-M cage windings to withstand repeated starting stresses.

To get top performance from your large compressor drives, discuss your needs with your nearest E-M sales engineer. And write factory for E-M Synchronizer No. 42, a special issue on the ABC'S of Synchronous Motors.

ELECTRIC MACHINERY MFG. COMPANY
MINNEAPOLIS 13, MINNESOTA

E-M

1200-TPA-2168 A

Specialists in making motors do
EXACTLY WHAT YOU WANT THEM TO

TIPS FROM A ROLL MAKER'S NOTEBOOK

MACKINTOSH-HEMPHILL DIVISION, E. W. BLISS COMPANY, Pittsburgh 3, Pennsylvania

Cast mill rolls • Johnston cinder pots • rotary tube straighteners • end-thrust bearings • heavy-duty lathes • steel and special alloy castings

Tooling: key to longer roll life between redressings

Most difficult roll turning job done regularly at Mack-Hemp is dressing pipe mill rolls. Turning takes a week or more, with carbide tools reground three or four times per hour.

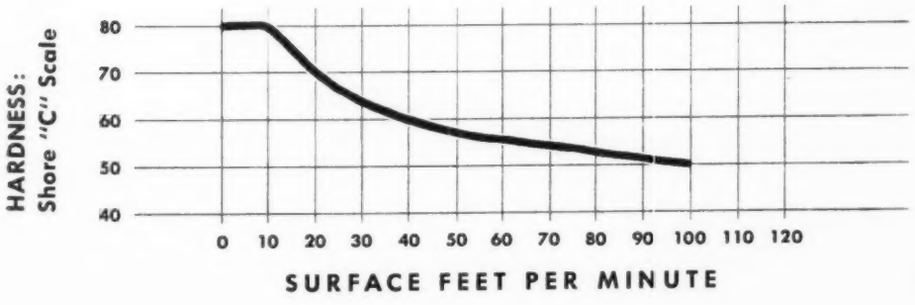
In a very important sense, block lathe turning practice sets the upper limit on the production-per-turn of every rolling mill in a plant. The reason is obvious. If the roll shop won't turn rolls whose hardness is above a certain figure, then the extra wear resistance of these harder rolls can never be brought into play.

In investigating roll shop machining techniques, we've found that many roll shop men are often not fully informed of the remarkable increases in turning speeds, feeds and depths of cut made possible by carbide tools. High speed cutting tools can dress rolls of hardness up to approximately 68 Shore (C scale), but carbide tools can cut harder rolls up to and including pipe mill rolls that are nearly 80 Shore. A set of these extremely hard rolls recently rolled 3500 miles of pipe between dressings!

Higher turning costs can pay dividends

At these higher-hardness levels, turning a large roll takes time and care; correct speeds must necessarily be selected and feeds are sometimes reduced to only a few thousandths of an inch. And even with a comparatively low rate of metal removal, the cutting tools must be reground after every few hundred surface feet. Three to four tools are worn out on every roll. *But* . . . the dividends in service life pay for the turning costs many times over.

Since Mack-Hemp specializes in rolls, roll turning and large roll contouring lathes, our experience in these three fields together with our awareness of the high tonnages available from the harder roll grades, helps us to make intelligent recommendations to our customers' best advantage. Suggestion: if you have had difficulty in the turning of hard rolls and want to explore their use in your mills, why not give us a call? Address Mackintosh-Hemphill Division, E. W. Bliss Company, 901 Bingham Street, Pittsburgh 3, Pa.



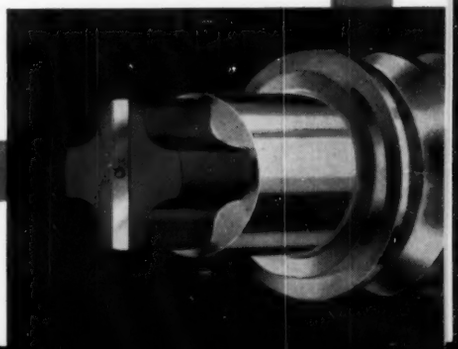
Cutting speeds (approximate) used by Mack-Hemp's machining department. Feeds and depths of cut vary widely depending on the roll and the power of the lathe available. These speeds are offered simply as a guide and should be adjusted to individual requirements.

MACKINTOSH-HEMPHILL

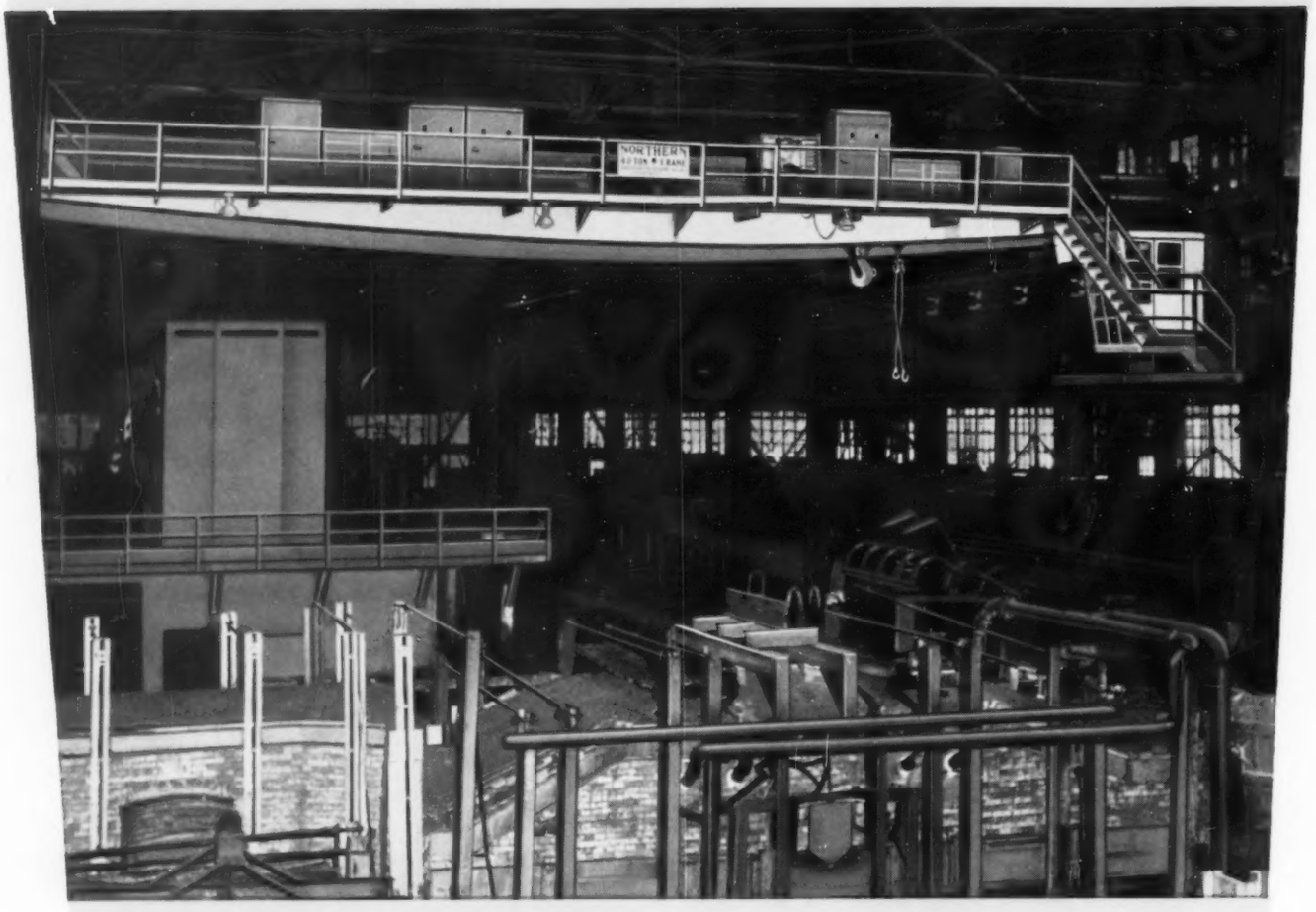
You get more tonnage from the rolls with the Striped Red Wabblers

Division of E. W. BLISS COMPANY

Presses, Rolling Mills, Special Machinery



Look overhead..see "NORTHERN"



Production Tooling for Production Materials Handling

Mechanized production processing — automation — with its hooking up of special purpose units, devices and controls designed to increase productivity — must be increasingly dependent on special purpose production tooling of all kinds—including overhead materials handling equipment.

NORTHERN OVERHEAD ELECTRIC TRAVELING CRANES—for wide spans—capacities up to 150 tons — when correctly custom-built for special purpose use — can quickly earn their cost in only a few years when they are fully integrated in your production planning.

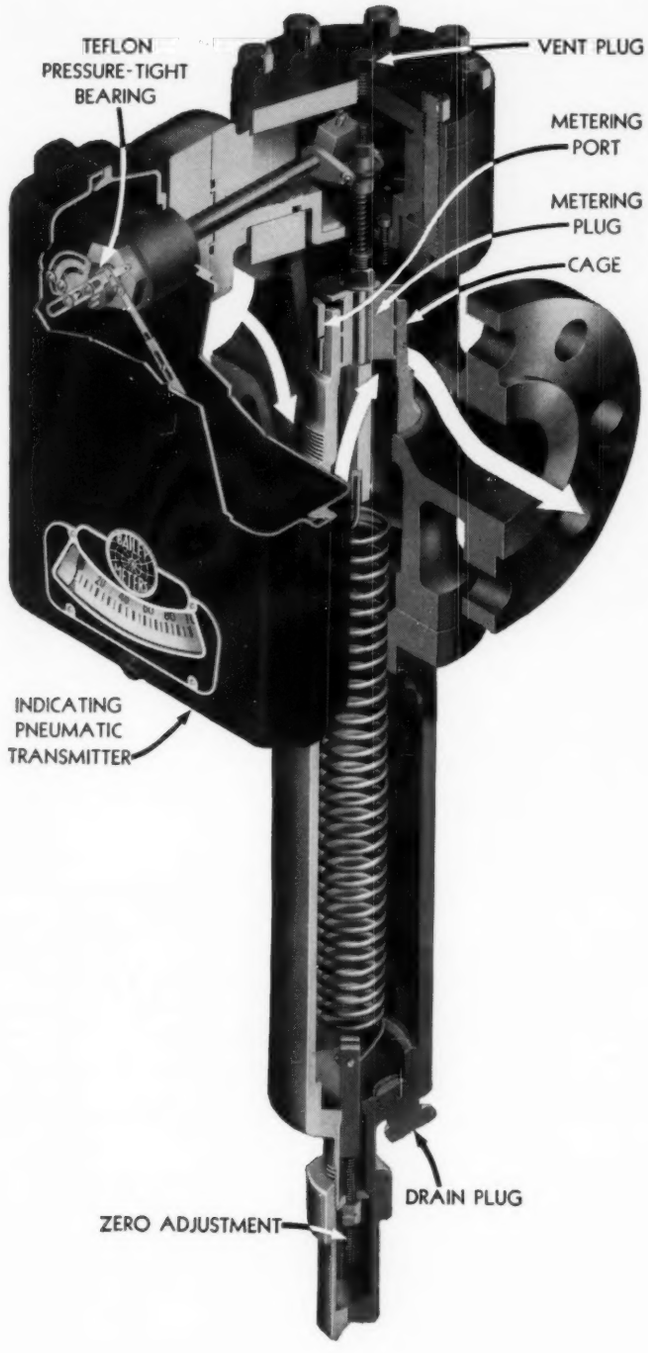
Let us send you Technical Bulletin W-101.

NORTHERN CRANES—HOISTS—TRAVELATORS

NORTHERN ENGINEERING WORKS

210 CHENE ST. • DETROIT 7, MICH.

NOTHING WEARS OUT
in the BAILEY AREA METER
for flow measurement



Simple design and sturdy construction in the Bailey Area Meter mean virtually no maintenance. Grit and dirt in liquid fuels do not harm this meter. Thus, long, trouble-free service under demanding steel mill conditions is assured.

Stainless steel is used for all vital operating parts, so meters can handle corrosive fluids and withstand corrosive atmospheres associated with steel making. Whether you are metering oil, pitch, or tar for open hearth fuel, water for a pickling process or any of a number of other fluids, you can install a Bailey Area Meter in the line and forget it.

The principle of operation is simplicity itself. The metering plug moves directly proportional to rate of flow.

Pneumatic Area Meter Transmitters indicate flow and provide a signal of 3-15 psig or 3-27 psig for indicating, recording, and controlling. Electric Area Meter Transmitters are also available. Both types are useful for fuel totalizing and/or control.

In a typical steel mill application, a Bailey Area Meter is used to measure the flow of Bunker C Oil and pitch to an open hearth furnace. A control system operated by the Area Meter maintains constant flow rates as determined by the operator based on temperature of the molten metal and the roof temperature. After each use of pitch, the meter is steamed out, thus making it available for fuel oil. The thermal and mechanical shock of steaming has no effect on the $\pm 1\frac{1}{2}\%$ accuracy.

The Bailey Area Meter measures flow over a 50 to 1 range. Range spans are 0-550 lb/hr to 0-108,000 lb/hr. The Bailey Recorder used in conjunction with the transmitter may be calibrated in terms of gallons, pounds, or cubic feet per minute. It receives and continuously records one to four pneumatic or electric signals in any combination.

A Bailey Engineer will be glad to call at your plant and explain how you may use this meter. Or, you may wish to write our Iron & Steel Division for Product Specifications P22-4 and E22-4. S-7-1

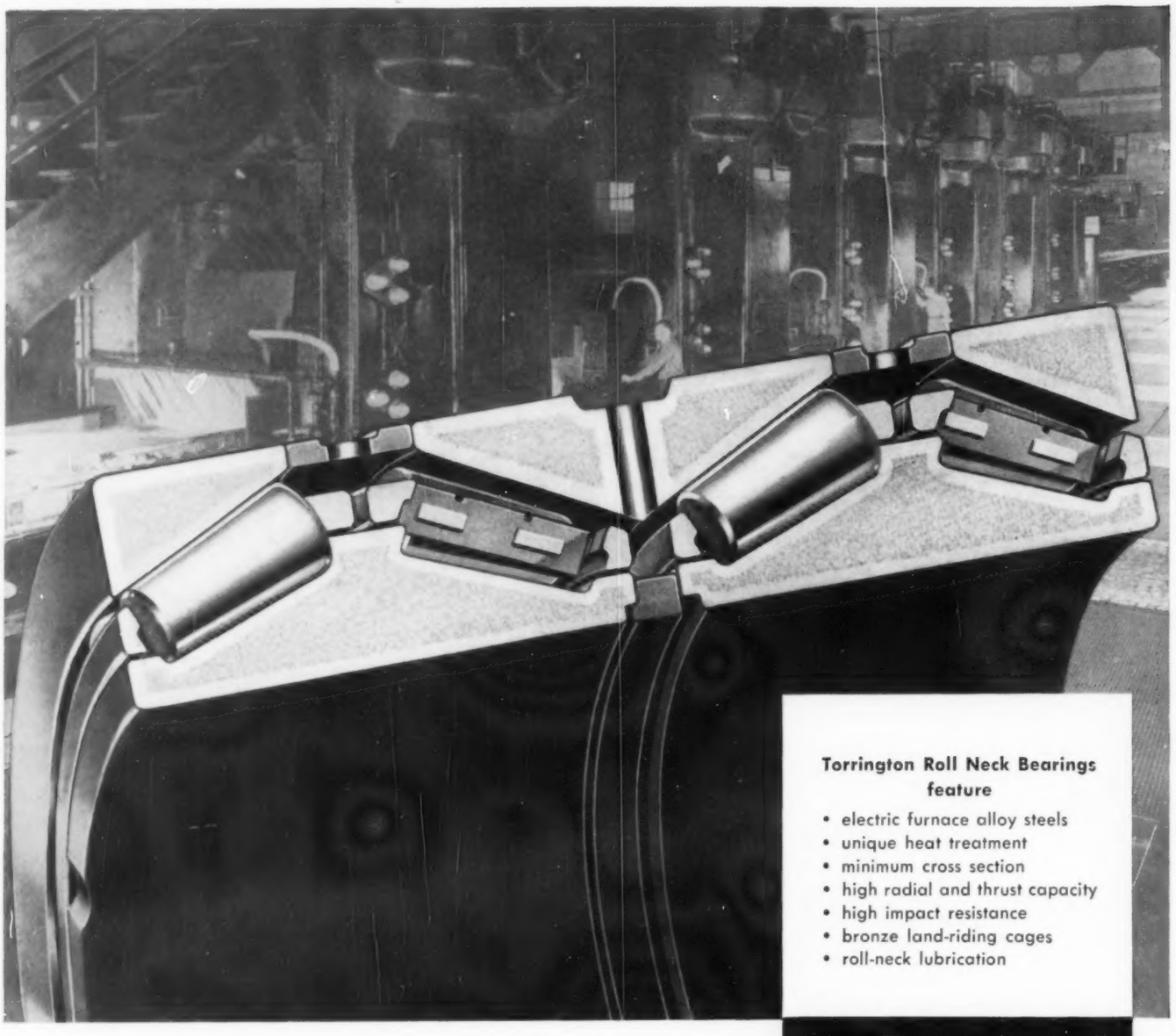
Instruments and controls for power and process

BAILEY METER COMPANY

IRON AND STEEL DIVISION, 1047 IVANHOE ROAD, CLEVELAND 10, OHIO

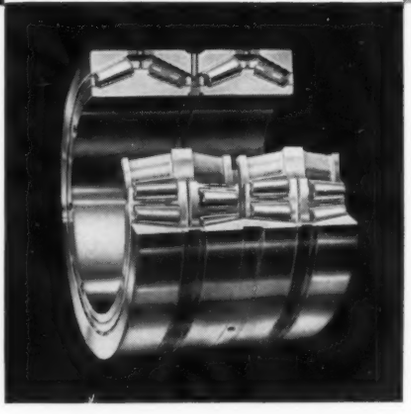
In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS



Torrington Roll Neck Bearings feature

- electric furnace alloy steels
- unique heat treatment
- minimum cross section
- high radial and thrust capacity
- high impact resistance
- bronze land-riding cages
- roll-neck lubrication



Torrington Roll Neck Bearings stand out in performance

Where tonnage rolled and down time saved are the measure of performance, Torrington Roll Neck Bearings stand out.

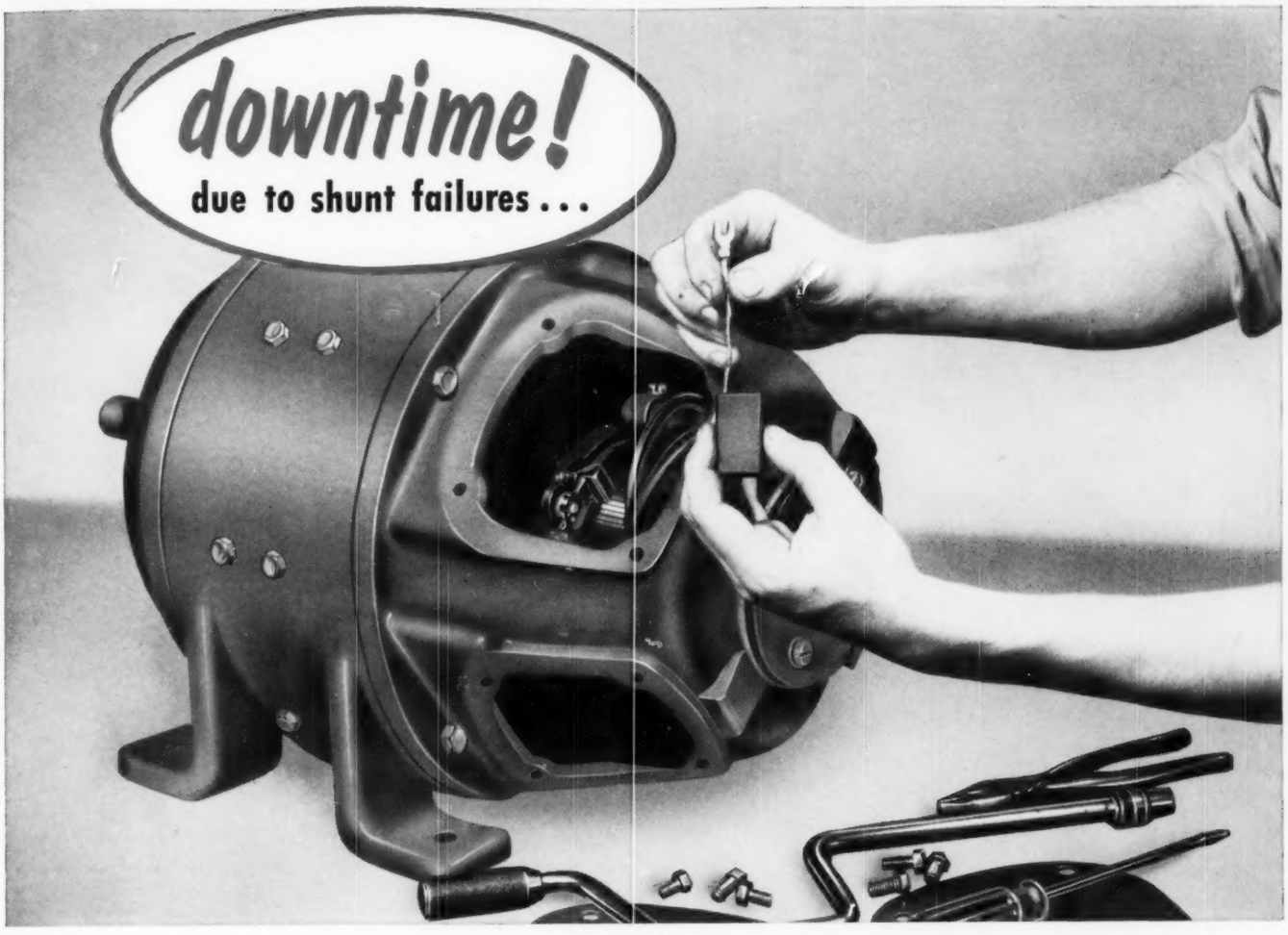
For toughness, surface hardness and uniformity, only the highest quality electric furnace alloy steels are used. Advanced heat-treating technique produces maximum impact resistance and optimum wear quality. These refinements permit use of larger diameter rollers and steeper angles with no increase in bearing boundary dimensions. To minimize roll-neck galling under creep conditions, lubricant grooves are provided on cone faces.

Over a quarter century's experience in supplying the finest bearings to the steel industry makes Torrington quality a byword in the industry. Torrington Roll Neck Bearings measure up to your most exacting requirements for rolling mill applications. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST



can be prevented by USG® BRUSHES . . .

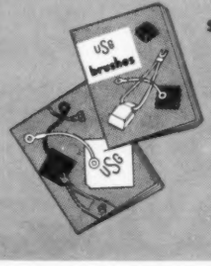
with STATITE® permanent shunt connections

When a motor is out . . . you're money out. If you want to eliminate downtime caused by shunts jarring loose or being pulled out, we suggest you try USG Brushes with Statite. Statite is a permanent shunt connection needing no hammerclips. It can't be jarred out even under severe operating conditions, and will assure your electric motors of steady, maintenance-free performance. In addition, Statite shunt connections, which eliminate troublesome rivets, retain their original low millivolt shunt drop, cannot oxidize, and are unaffected by temperature extremes. USG Brushes are manufactured in a variety of types and sizes for all applications from fractional horsepower to diesel generator. Grades available include carbon and carbon-graphite, electrographitic, graphite, metal graphite, and silver graphite.

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 9, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



SEND THE ATTACHED COUPON . . .
for Engineering Handbook B-56 and Brush Grade Supplement.

231

THE UNITED STATES GRAPHITE COMPANY
SAGINAW, MICHIGAN

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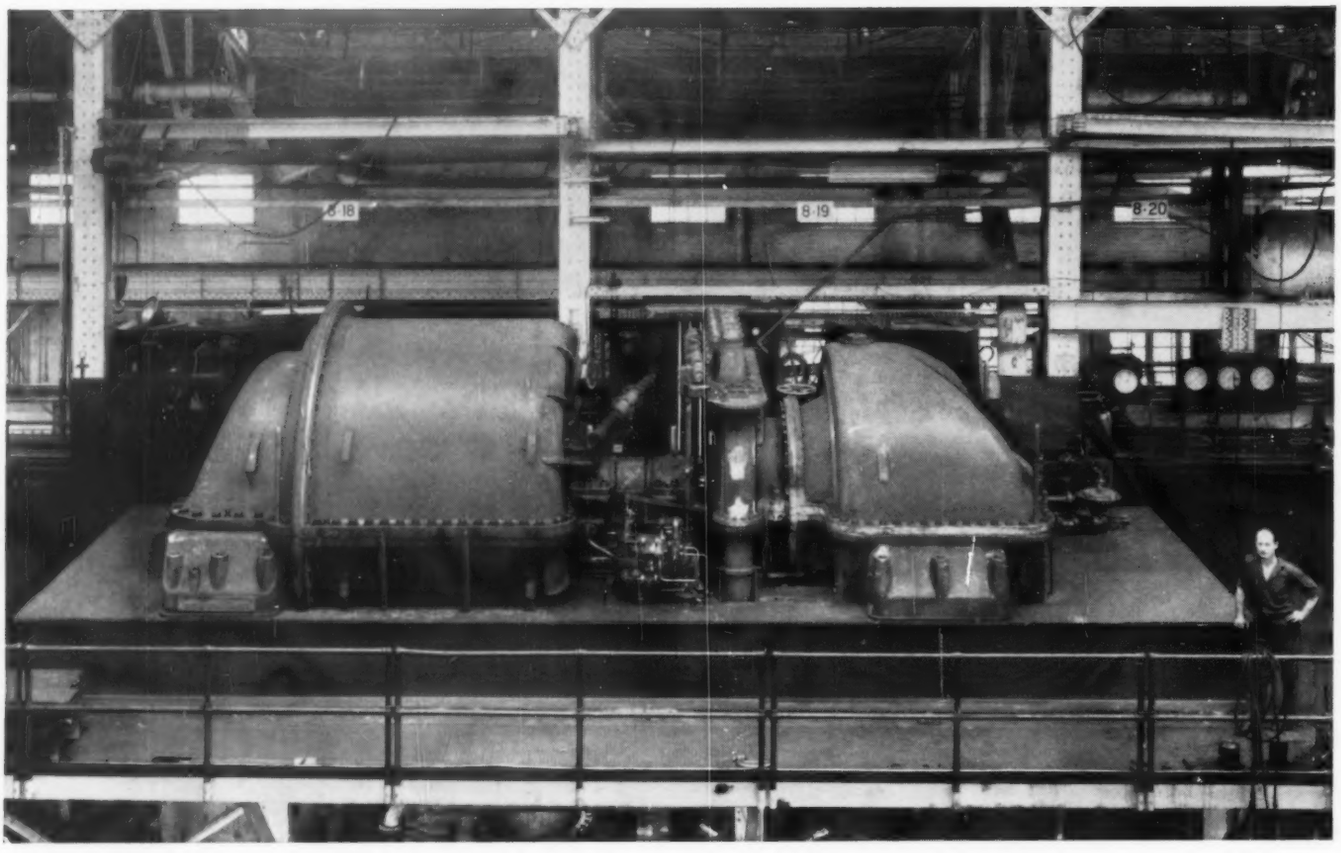
FIFTH I-R Blast-Furnace Blower for INDIA'S LARGEST STEEL MILL



Tata Iron and Steel Company again selects an Ingersoll-Rand steam-turbine-driven blower

IN the photo above, an Ingersoll-Rand Turbo-Blower is undergoing final performance tests at the factory in Phillipsburg, N. J., prior to shipment half way around the world. Destination—India.

There it will join four other I-R Turbo-Blowers in blast-furnace service at the Tata Iron and Steel Co. plant in Jamshedpur. This unit is rated at 125,000 cfm, 35 psig discharge, and is driven by a 15,750 hp I-R steam turbine. It will bring Tata's total number of Ingersoll-Rand blast-furnace turbo-blowers to 5—all with I-R steam turbine drives representing a total of over 50,000 hp.

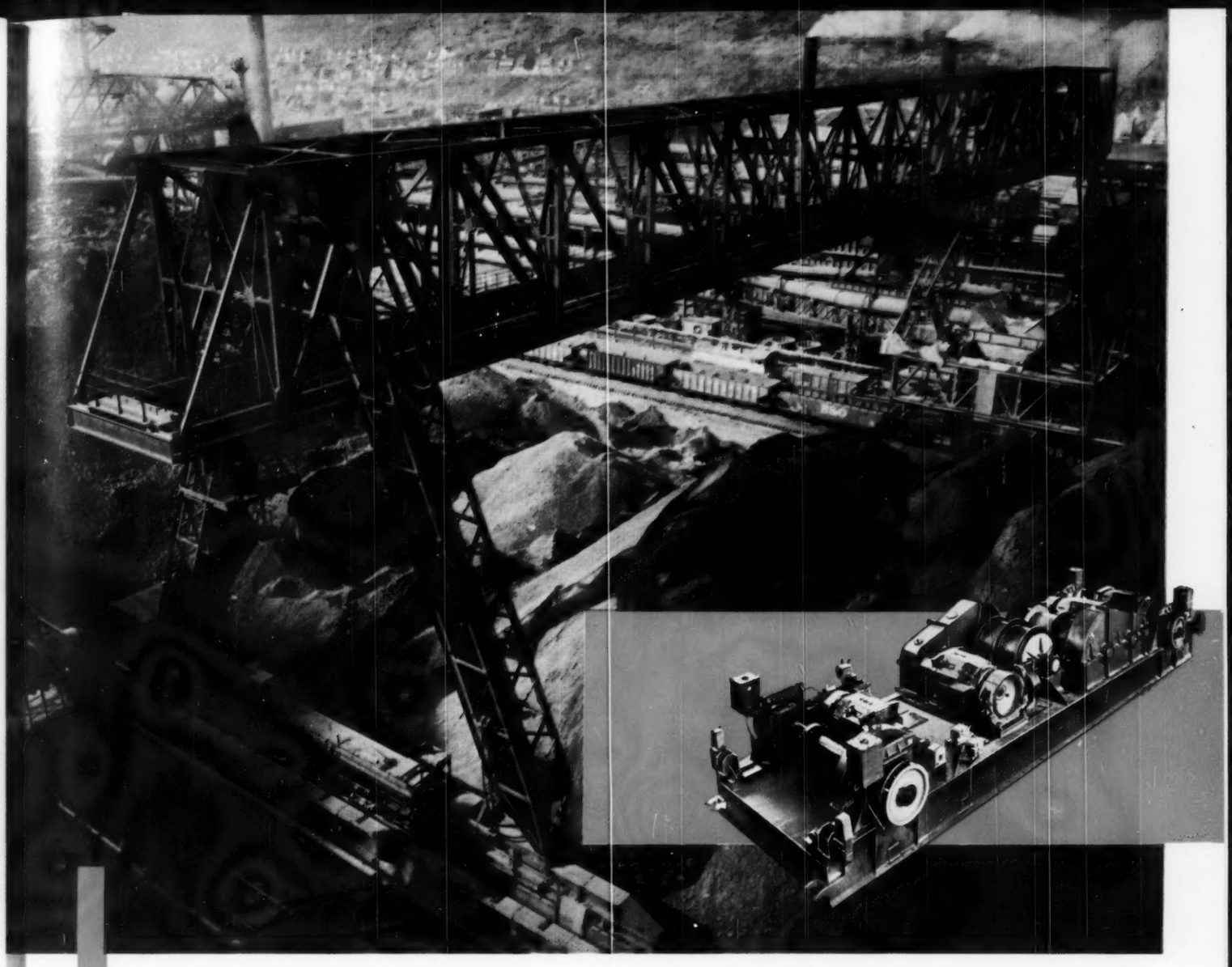
These repeat orders from far-off India reflect years of successful operating experience with other Ingersoll-Rand Turbo-Blowers and steam turbines—the first unit was shipped in 1938. Here, again, one of the world's leading steel producers has placed *quality* first by specifying I-R turbo blowers of *proved dependability*.

For specific information on Turbo-Blowers best suited to your requirements, call your Ingersoll-Rand engineer. His knowledge and experience can save you time and money from initial planning to final installation.

Ingersoll-Rand
11 Broadway, New York 4, N. Y.

12-698

PUMPS • COMPRESSORS • DIESEL ENGINES • AIR & ELECTRIC TOOLS • TURBO BLOWERS CONDENSERS



H & P Ore Bridges, the NO. 1 Servants of America's Blast Furnaces...

MANY HEYL & PATTERSON BRIDGES INCLUDE THESE FEATURES:

- **H & P automatic hydraulic rail clamps for bridge safety.**
- **H & P automatic hydraulic buffers for trolley safety.**
- **Wide flange beam construction to reduce maintenance.**
- **Aluminum contact conductors.**
- **Worm gear driven trucks...fully equalized.**
- **Adjustable voltage control for smooth trolley operation and more accurate bucket control, for faster duty cycles, for reduction of trolley weight, for drastically lowered power consumption.**

Busy Blast Furnaces rely on H & P Ore Bridges for High-capacity stocking and reclaiming, uninterrupted service and low-cost operation . . . in short, satisfactory performance from every angle.

Operational records of more than half-a-century prove that H & P designs, builds and erects Ore Bridges for dependable, safe and long-lasting service. These bridges are often teamed with a Turnover Car Dumper or other H & P Bulk Material Handling Equipment. So, quite frequently it is . . .

ORE HANDLING ALL THE WAY WITH H&P

Since 1887...

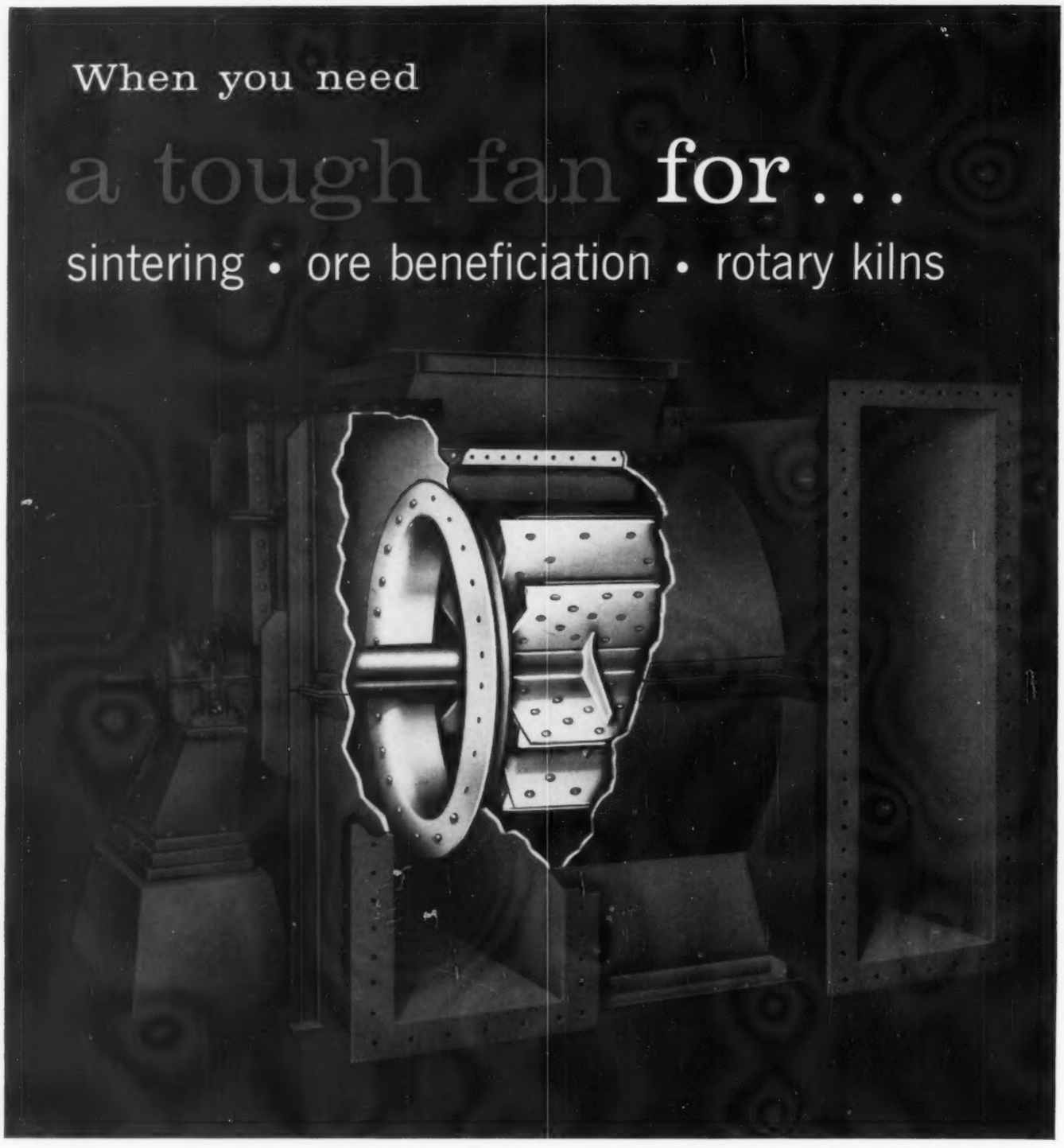
Heyl & Patterson INC.

55 FORT PITT BLVD. • PITTSBURGH 22, PA.

When you need

a tough fan for . . .

sintering • ore beneficiation • rotary kilns



Use Westinghouse erosion-resisting fans:

Designed specifically to handle abrasive gases at elevated temperatures and high pressures!

Superior Wheel Design:

Open wheel (no side plates) with radial tapered blades provides low stress and long rotor life.

Erosion Resistance:

- Ribbed blade liners for severe abrasive service.
- Flat blade liners to prevent material build-up.
- Flat housing and scroll liners.

All liners easily replaceable in the field.

More Information?

Call your nearest Sturtevant Division Sales Engineer, or write Westinghouse Electric Corporation, Department E-21, Hyde Park, Boston 36, Mass.

J-80644

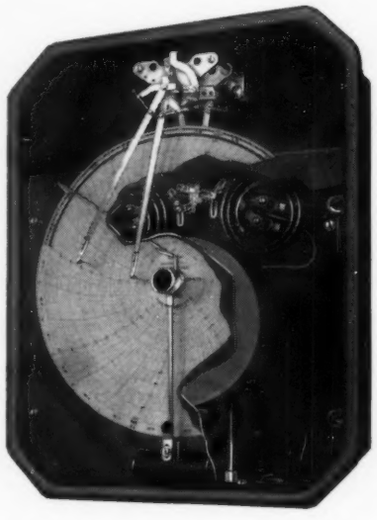
YOU CAN BE SURE...IF IT'S Westinghouse

MEASUREMENT and CONTROL PROBLEMS?

Bring 'em to Taylor!

Simple problem or complex headache—if it has to do with instruments your Taylor Field Engineer is a good man to see. Taylor instruments are known throughout industry for their dependability, accuracy and ruggedness. Just as important, Taylor Engineers are highly trained, widely experienced in dealing with all kinds of application problems and always at your service. Illustrated here are just two types of recording instruments and a simple industrial thermometer. The Taylor line includes transmitters, controllers and receivers (both indicating and recording) for a wide variety of applications. The trade name FULSCOPE* for example has become synonymous with quality and dependability in temperature, pressure and flow control. The TRANSET* line of miniature "plug-in" instruments is flexible, economical and ideal for use on graphic panels or small sized conventional panels. To find out how Taylor instruments can go to work for you, call your Taylor Field Engineer, or write for **Bulletin No. 98261.**

Taylor Instrument Companies, Rochester, N. Y., and Toronto, Ontario.



No. 75JM Temperature Recorder. ACCURATUS* Mercury Actuated Thermal System gives an extremely high order of accuracy, because ACCURATUS tubing fully compensates for fluctuating temperatures along the connecting tubing between sensitive element and instrument case. This exclusive Taylor tubing also means that the instrument may be mounted 200 ft. or more from the point of measurement. Wide selection of standard charts, within limits of minus 40° and plus 1,000F°., or equivalent C.

BI-THERM* Bimetallic Dial Thermometer. Available with 3" or 5" dials and a complete range of stem lengths and temperature scales. All-welded stainless steel construction with hermetically sealed bezel. Silicone damping prevents pointer chatter and improves speed of response. Simple zero set adjustment. Unaffected by ambient temperature changes—accuracy well within 1%.

No. 76JF Pressure Recorder. For recording one, two or three Gage Pressures. Provides a permanent, legible and accurate record. Chart changing is a simple one-hand operation, because pen lifter is combined with chart locking device. Case of die-cast aluminum, designed for face or flush mounting. Highly resistant to vibration. All parts easily accessible for adjustment and interchangeable with other Taylor instruments.

Instruments for indicating, recording, and controlling temperature, pressure, flow, liquid level, speed, density, load and humidity.

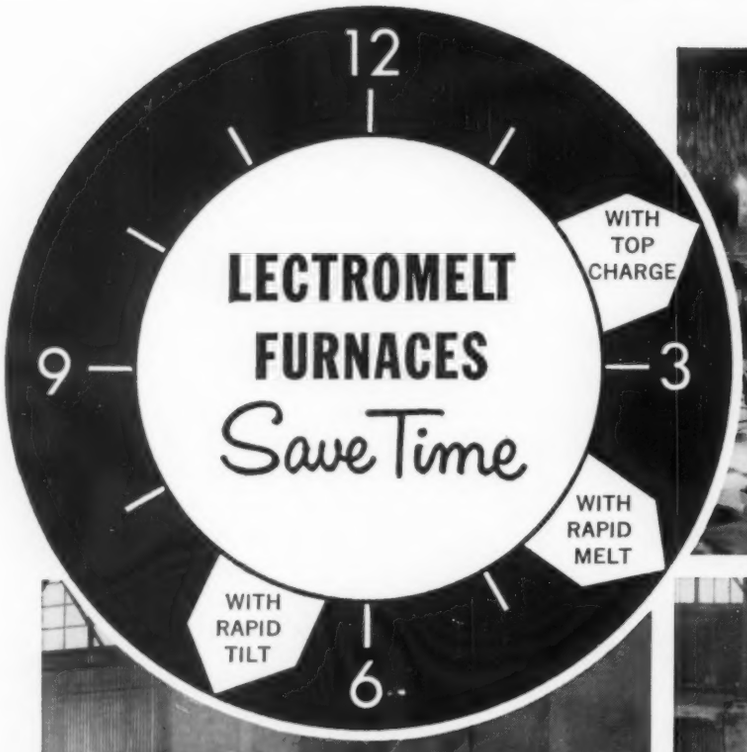
*Trade-Mark

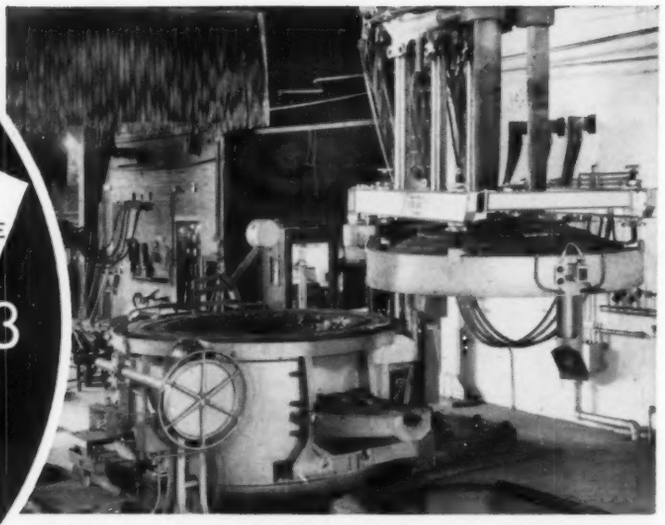
Taylor Instruments

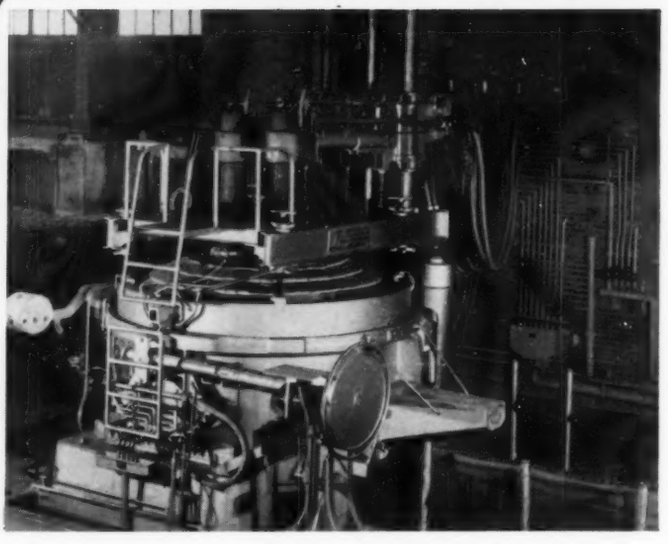
MEAN

ACCURACY FIRST

VISION · INGENUITY · DEPENDABILITY







When you melt... LECTROMELT*

TOP CHARGING provides smooth, fast turn-around in furnace operation—less downtime between heats and less heat loss. Linings and electrodes last longer.

HIGH POWER INPUT allows rapid metal melting. Lectromelt makes this possible with large transformers and leads, more efficient cooling and heavier furnace construction.

RAPID TILTING is accomplished smoothly and safely. Mechanism is accurate, strong and side-mounted—located out from under, where it won't get clogged by spillage.

Catalog 10 describes Lectromelt Furnaces. For a copy, write Lectromelt Furnace Division, McGraw-Edison Company, 310 32nd Street, Pittsburgh 30, Pennsylvania.

*Reg. Trademark U.S. Pat. Off.

McGRAW EDISON

Lectromelt

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Oxygen and the Steel Plant

Oxygen usage in steel plants has grown at a remarkable rate in the past ten years . . . . the ability to increase production with existing equipment, the better product thus obtained, and the availability of large quantities of oxygen at economic cost have been important factors in this development.

"SUMMARY OF OPERATING RESULTS"

by J. H. STRASSBURGER
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DURING the last 12 years the use of oxygen in iron and steelmaking has increased to such a marked degree that we might term the oxygen iron and steelmaking practices as being some of the outstanding contributions to increased iron and steel production during the past decade. This development work started approximately in 1946 at which time oxygen was introduced into open hearth furnaces for accelerated combustion through the burner and also for decarburization of the open hearth heat by lancing oxygen into the bath of the furnace. Both of these practices are now quite widespread throughout the industry, resulting in shorter open hearth heats with increased production. The use of oxygen in this way has resulted also in decreased fuel costs which compensates for the cost of the oxygen supplied. In addition to the use of oxygen in the open hearth furnace, the lancing practice was closely followed by the electric furnace plants so that this practice is also used in a great many electric furnaces today for shaping up the heats, decarburizing and speeding up electric furnace steel production.

As an outgrowth of the oxygen converter, the development of oxygen lancing through the roof of an open hearth furnace has now been developed by several steel plants for increasing open hearth production. Jetting of oxygen on the open hearth bath speeds up the heat, not only by carbon reduction but also by accelerating the melting of scrap and the shaping up of the heat. Up to 500 cu ft of oxygen is used per ton of ingots with this lancing operation.

After the initial trials with oxygen and open hearth furnaces, oxygen was then experimentally used for enriching the blast of bessemer converters in order to speed up the blowing of iron and also for the melting of additional scrap. This practice is being followed today by several plants as a means of increasing bessemer converter production. In the late 1940's and early 1950's, the development of the top-blown oxygen converter in Austria was one of the outstanding contributions in the form of a new steelmaking process

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with the entire heat for the production of steel supplied by the oxygen reacting with the molten metal bath. This process uses about 2000 cu ft of oxygen per ton of ingots and is one of the largest users of oxygen in making steel. The top-blown converter has been installed in several plants on the North American continent and the quality of steel and economic results have proved to be satisfactory for the types of steels produced. The use of oxygen for the conversion of iron to steel has also been given impetus by work in both Sweden and Germany where other types of oxygen furnaces are under development at the present time. Also in Europe it is usually common practice today for all of the bottom-blown Thomas converters to enrich the blast up to 28 to 30 per cent oxygen in order to obtain not only faster heats but also to obtain a better quality of Thomas steel by reducing the nitrogen content of the steel by the addition of oxygen in the blast. In surveying the European Thomas converter plants in Germany, Belgium, Luxemburg, France, England and Sweden, we find that it is most common to find an oxygen plant of 100 to 200 tons daily capacity for supplying oxygen to the converter operations.

The use of oxygen in blast furnaces for increasing iron production has also been a development during the past decade. Following the work of Lennings in Germany during the 1930's, enrichment of the blast for blast furnace operation was started by the Weirton Steel Co. Division of National Steel Corp. in 1951. After 6½ years of operation with oxygen used from 1 up to 4 per cent enrichment, we have found that the use of oxygen in the blast of a blast furnace has resulted in increased iron production and smoother working furnaces. At the present time, a ferromanganese furnace operation is now on oxygen enrichment and we understand shows quite satisfactory results in both increased ferromanganese production and a marked decrease in coke rate.

The use of oxygen in the blast furnaces has also pinpointed a secondary practice which resulted from the use of oxygen enrichment. From the start of the practice of using oxygen in the blast furnace at Weirton, we have found that increased moisture in the blast was necessary in order to obtain the optimum results from the oxygen enrichment. The use of moisture with oxygen then showed the way to using increased moisture with increased blast heat for further accelerating iron production. At the present time we have used up to 28 grains of moisture in the blast of a 25 ft-6 in. hearth diameter blast furnace with 4 per cent oxygen and 1600 F blast heat, all resulting in a decidedly marked increase in iron production. This particular size furnace at Weirton was nominally rated at about 1200 tons of iron daily. At the present time this furnace is producing over 1700 tons of iron daily or about 3.4 tons per sq ft per day, all resulting from a combination of oxygen enrichment, high blast heat, moisture in the blast and improved burden.

During the past ten years, the development of the continuous hot scarfing machine has also resulted in a decided increase in oxygen requirement for the desurfacing of semifinished steel. Continuous scarfers, first of two-sided and then of four-sided construction, have been developed with many of these units now in operation. With the scarfing of slabs, a continuous scarfing unit will require from 100 to 150 cu ft of oxygen per ton of steel scarfed.

In summarizing the use of oxygen in the various steelmaking operations, the following is a rough estimate of the quantities now being used in the various operations:

Open hearth lancing	150 to 300 cu ft per ton of ingots.
Open hearth jets through the roof	100 to 500 cu ft per ton of ingots
Open hearth combustion	125 to 500 cu ft per ton of ingots.
Bessemer converter	400 to 500 cu ft of oxygen is required per ton of converter production.
Top-blown oxygen converters	1800 to 2200 cu ft per ton of ingots.
Hot scarfers	100 to 150 cu ft per ton of slabs.
Blast furnaces	1200 to 4500 cu ft per ton of pig iron at 1 to 4 per cent enrichment.

As can readily be seen all of the above practices in using oxygen add up to a tremendous increase in the use of oxygen in iron and steelmaking. When it is considered that this development has practically all taken place within the past 11 to 12 years, it is our opinion that the use of oxygen will continue to increase beyond the practices of the present time with further marked increases in iron and steel production.

MAINTENANCE OF OXYGEN PRODUCING PLANTS

National Steel started during the beginning of 1946 to operate three 2-ton oxygen plants producing a product of 99.5 per cent purity. The use of high purity oxygen for lancing, scrap cutting, oxygen and steel plant operations has increased to the present time so that National Steel is now operating six 25-ton oxygen plants, four at Great Lakes and two at Weirton. In addition to the 25-ton plants, the Weirton Steel Division of National Steel has been operating since February, 1951, a tonnage oxygen plant producing over 500 tons daily of 90 to 95 per cent purity; the bulk of this oxygen is used in the blast furnaces with a small amount in the open hearth and bessemers. Experience in the maintaining of oxygen plants has been quite satisfactory.

99.5 Per Cent Purity—The high purity 25-ton oxygen plants have been in operation for approximately 1½ to 2 years' time. The ability to maintain these plants in practically continuous service has resulted in a satisfactory oxygen supply with a minimum interruption of supply which is quite readily taken care of by oxygen storage facilities. The No. 1 25-ton plant at Weirton was put on stream on February 17, 1956. Since that time, the heat exchanger of this plant has been defrosted once with a replacement of both liquid oxygen pumps and a replacement of the valves in the air compressor during the past 19 months. The No. 2 plant was put on stream on November 27, 1955. Since that time, the heat exchanger of this plant has been defrosted once with a new crosshead and a change of valves in the air compressor. The total downtime of these two 25-ton plants,

including the major repairs as outlined above, together with time lost in repacking the liquid oxygen pumps, has amounted to the following:

No. 1 Plant....225 hours' downtime in 19 months, or an availability of over 98 per cent.

No. 2 Plant....104 hours' downtime, or an availability of over 99 per cent.

In addition to the maintenance work as outlined above, each of these 25-ton plants is given a complete lubrication and oil check once per week in addition to spot lubrication as required and taken care of by the operator.

500-Ton Plant—The 500-ton plant which had been operated during the past six and one-half years has shown during this period a progressively more stable operation. It was natural in the starting up of the first large tonnage oxygen plant in the United States that some operating difficulties would develop during the initial stages of operation; however, at the present time this plant should operate for approximately a one-year period without a shutdown. The yearly shutdown, in our opinion, is necessary in order to inspect the 12,000-hp turbo-compressor both on the steam and the air end, as well as to recheck the mechanical equipment on the oxygen plant proper so that the plant can be maintained in good enough mechanical condition, so that it can operate for a twelve months' continuous period with a minimum of interruption. The operation of oxygen plants has been found no more difficult than any other mechanical type of steel plant operation and the skills required would comprise that of operators who are capable of running turbo-blowers, air compressors and the operation of still equipment such as is common practice in the coke-plant benzol by-product divisions. The results during the past 11 to 12 years in operating oxygen plants have shown that oxygen can be produced with the type of skills available in a steel plant and that a reasonably continuous operating practice can be expected.

"BENEFITS OF PURCHASED O_2 TO THE INDIANA HARBOR WORKS OF THE INLAND STEEL CO."

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IN discussing the benefits to Inland by the use of purchased oxygen, it seems appropriate to give a brief history of oxygen usage, a description of oxygen facilities and method of supply, and reasons for selecting this method.

HISTORY OF OXYGEN USAGE

The use of oxygen has played an important part in the history of the Inland Steel Co.: first, as a tool in the field of maintenance and construction; second, for removing surface defects from steel slabs and blooms by hand scarfing and later by machine scarfing; and third

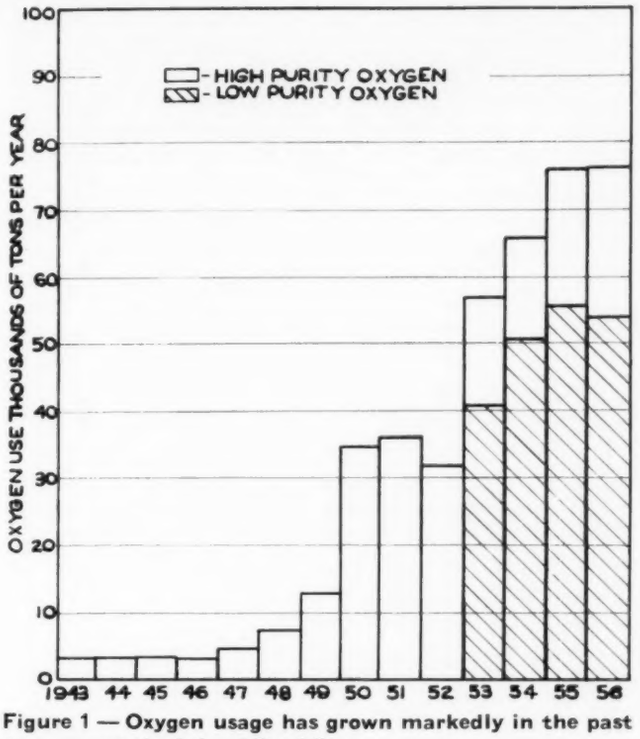


Figure 1 — Oxygen usage has grown markedly in the past ten years at the Inland Steel Co.

and largest use at the present time, to increase the production of open hearth furnaces by the use of oxygen for decarburization and combustion.

The growth of oxygen consumption at Inland was fairly slow until 1947 when the upward trend became quite pronounced. Figure 1 shows the consumption in thousands of tons per year from 1943 to 1956. During this period the average daily utilization has increased by more than 2400 per cent, from less than 9 to over 200 tons per day.

In order to understand the growth of oxygen usage and benefits gained thereby, let us trace the development in each major area.

Oxygen has been used for cutting and welding for many years. This is a vital application today; however, in recent years, volumes required for this purpose have been overshadowed by the development of other uses.

Oxygen was first used for the removal of surface defects from steel at Inland in 1936. The oxygen-acetylene torch was used to burn out defects from the steel surface, an operation which was previously performed by chipping with a pneumatic chisel. By replacing the pneumatic chisel with the oxygen-acetylene torch it was possible for one man to surface condition over seven times as many tons of steel slabs as before. Although the use of torch scarfing resulted in a reduction of the man-hour requirements for surface conditioning of steel, the space for laying down the slabs, for inspection and conditioning and the material handling facilities required, remained unchanged. Improvements from this standpoint were made with the use of the hot scarfing machine.

The first hot scarfing machine was installed in 1940 at No. 3 blooming mill. It was placed in the roller line immediately after the mill and the hot slabs passed through it. On each side of the machine there were several oxygen-acetylene nozzles spaced about 1¼ in. apart which burned off a layer of steel, removing with it

most of the surface defects. This machine, referred to as an edge scarfer, made it possible to meet the increasing demands for better edge quality without a corresponding increase in manpower and material handling facilities. In 1952, the edge scarfer was replaced by a four-sided scarfing machine which conditioned the top and bottom surfaces as well as the edges.

At No. 2 blooming mill, which produces blooms and shapes as well as slabs, a four-sided bloom scarfing machine was installed in 1941. This machine was replaced in 1956 by a four-sided scarfer capable of handling both slabs and blooms.

The use of the scarfing machines resulted in a decrease in the labor required to condition a ton of steel by more than 80 per cent when compared to hand methods alone, and a corresponding decrease in the space and material handling facilities required. Hand methods are still required when defects are encountered which are so deep that it is impractical to remove them by machine scarfing alone. Hand scarfing and some chipping is also used in the conditioning of products from mills which are not equipped with hot scarfing machines.

In the space of the twenty years since oxygen was first used for surface conditioning of steel, the Indiana Harbor Works' requirements for this purpose have grown to over 50 tons per day. In the same period the cost of oxygen has been reduced by more than 80 per cent. The combination of decreased oxygen cost and improvements in the machinery for its utilization, have permitted increased tonnage of surface conditioned steel at a much lower cost than would have been possible using hand methods alone.

The third major use for oxygen at Inland was to increase the productivity of existing open hearth furnaces. Experiments with oxygen for combustion were conducted first at No. 1 open hearth shop in 1946. An increase in production was realized; however, its use was determined to be unfeasible at that time.

Experiments were commenced in the use of oxygen for decarburization at No. 2 open hearth in 1947. The initial tests were very promising, resulting in both a reduction in the time required to produce a heat and in fuel consumption. These tests were continued at an accelerated rate and were expanded in 1948 to include the use of oxygen for combustion. By using oxygen for combustion, greater heat input rates were possible without the necessity of increasing combustion air, induced draft capacity or other furnace alterations. The increased heat input rates resulted in a decrease in production time mainly by shortening the scrap melt down period.

The over-all increase in production by the use of oxygen at No. 2 open hearth was approximately eight per cent. Six per cent of this was attributed to its use for decarburization and two per cent to combustion.

The supply of oxygen was an important and closely integrated part of the history of oxygen use. Determining the relative position of supply and usage in the complex oxygen story is like determining which came first, the chicken or the egg. However, increased demand has made possible large volume production of oxygen and a reduction in cost, which has in turn resulted in further increased usage.

The oldest method of supplying oxygen to commercial users is by means of compressed gas cylinders. This method of supply is well suited for small volume requirements and where portability of the supply is important. However, because of the high cost of oxygen in this form, it is not practical for large volume requirements. Cylinders were Inland's only source of oxygen until a liquid storage and vaporizer unit was installed in 1937. This new method of supply was a major step toward large volume usage, both from a cost and quantity standpoint. The storage and vaporizer unit consisted of an insulated storage tank, a pump and a steam heated vaporizer. The storage tank contained the liquid oxygen which was delivered by tank truck. The pump delivered the liquid to the vaporizer where it was converted to a gas and delivered by pipeline to the point of consumption.

The supplier owned the storage and vaporizer unit and charges were made only for the oxygen used.

Because of increasing demands, particularly due to the open hearth experiments, the original liquid unit was replaced by a larger unit in 1948 and an additional unit was added in 1950.

The liquid system of supply has the advantage of extreme flexibility in meeting varying load demands. It can instantly meet requirements which vary from zero to the maximum capacity of the pump and heat exchanger. It is a very desirable means of supply for temporary or experimental large volume requirements when it is impractical to make the large capital expenditure required for a tonnage plant. It is also advantageous, when necessary to obtain large volumes of oxygen on short notice. These are the reasons why this method of supply was used for the open hearth experiments. We were able to obtain large quantities of oxygen on short notice and the possible requirement of a large capital investment, for a tonnage plant, was deferred until the economics of the use of oxygen had been definitely established and the approximate volume requirements known.

The liquid storage and vaporizer units were, and still are, a practical supply arrangement for moderate quantities of oxygen, which are not large enough to justify a tonnage plant. However, by 1950 the advantages of oxygen used in the open hearths were well established and the volume requirements were sufficiently large that it was deemed advisable to investigate possible methods of securing lower cost oxygen. More will be said later about the selection; however, the final decision was to purchase oxygen delivered by pipeline from a supplier's plant located near by. This is at present the major source of supply at Inland.

DESCRIPTION OF OXYGEN FACILITIES

At Inland there are three separate bulk oxygen systems. Low purity oxygen (95 per cent) is supplied to No. 2 open hearth shop for decarburization and flame enrichment and to No. 3 open hearth shop for decarburization only. High purity oxygen (99.5 per cent) is supplied throughout the plant by an extensive distribution system for use in steel scarfing, burning and welding operations. In addition, there is a gaseous storage unit which supplies oxygen to a scrap preparation field.

The gaseous storage unit consists of two banks of nine cylinders each, with a total capacity of 65,000 standard cu ft at 2200 psi. Oxygen for this system is delivered in

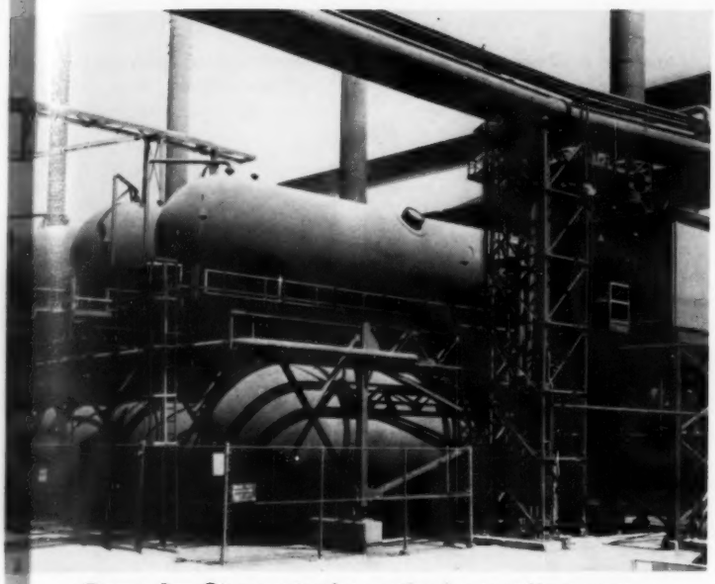


Figure 2 — Storage tanks are for low purity oxygen.

liquid form and vaporized before being injected into the cylinders. From the storage cylinders the pressure is reduced to 75 psi and delivered by distribution pipelines to 15 stations in the scrap preparation area. The selection of this system was made after weighing the cost of oxygen from it against that from the pipeline. The economics of the gaseous unit have changed since its installation because of a reduction in the cost of high purity oxygen by pipeline; therefore, consideration is now being given to the extension of the pipeline distribution to the area served by this unit.

Oxygen for the low purity system is delivered through an 8-in. extra heavy underground pipeline. This line extends from the supplier's plant to storage tanks located at No. 2 open hearth shop, a distance of approximately 2½ miles. The 8-in. line is larger than necessary for the delivery rates for which it was originally built; however, the selection of the larger pipe size had little effect on the total cost of installation and provided for a two to threefold increase in delivery rates to meet possible future requirements.

The low purity storage consists of nine cylindrical tanks, 54 ft long and 12 ft in diameter, with an effective storage capacity, between 120 and 250 psi, of approximately 450,000 standard cu ft. The tanks are arranged in a bank with five cylinders below and four above. To provide operating flexibility when it is necessary to make repairs to the tanks or lines, valves are arranged so that tanks may be shut off individually or in groups of three. The purpose of the storage tanks is to act as surge capacity to absorb the difference between delivery and consumption rates.

Figure 2 is a view of the low purity storage and control house.

Figure 3 is a schematic of the low purity oxygen system in the storage area.

Delivery pressure varies from 120 to 250 psi depending upon the storage tank pressure which is a function of consumption and delivery rates. Pressure to the open hearths is controlled to 120 psi by six 3-in. regulators connected in parallel. Three regulators are capable of handling the maximum demand.

From the regulators, oxygen is delivered to a 10-in. extra heavy line which runs the length of No. 2 open hearth shop with 4-in. drops to each of the 24 furnaces. The line then reduces to 8 in. and continues to No. 3 open hearth shop, a distance of over one mile. At the entrance to the shop, the line reduces to 6 in. and continues through the shop with 4-in. takeoffs to each of the seven furnaces.

Low purity oxygen is metered for billing purposes by the supplier before it is delivered to the pipeline. Inland has recording and integrating meters before and after the storage tanks, and to each of the open hearth furnaces. The primary function of the metering system is for cost accounting. By having the oxygen flow checked at several points, the meters can also be useful in detecting leaks or meter errors that may be overlooked on routine inspections. Accurate measurement is as essential in determining and controlling the efficiency of utilization of oxygen as it is for fuels.

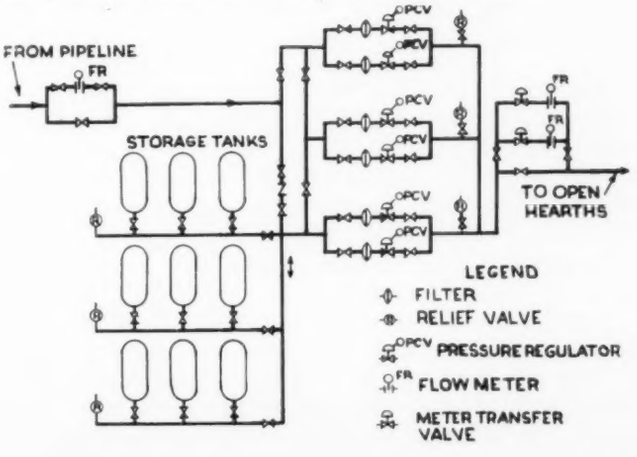
The high purity system consists of an 8-in. extra heavy underground line, parallel to the low purity line, from the supplier's plant to No. 2 open hearth shop, from this point an extensive distribution system originates, serving almost all areas of Plants I and II. Altogether there are approximately 14.5 miles of high purity oxygen distribution lines serving over 1000 stations.

Oxygen is delivered to the high purity system at pressures ranging from 140 to 160 psi. Pressure is regulated to the consumers to 100 psi by six regulating stations at various locations throughout the plant.

High purity oxygen is metered by the supplier before it enters the pipeline. It is metered by Inland as it enters the plant and at all major areas of consumption. Metering for this system has been generally satisfactory. From an engineering standpoint, the most severe problem encountered was the large fluctuations in flow caused by the scarfing machines. It is not uncommon for the flow to change rapidly from 10,000 to 280,000 cfhr. To handle this wide range of flow, a dual metering installation is used with ranges of 0 to 80,000 and 0 to 400,000 cfhr.

The low purity oxygen system was designed for the specific purpose of serving the open hearth furnace requirements and it still serves that purpose only. The high purity system, however, has grown from a system which served only one scarfing dock to a plant wide gen-

Figure 3 — Schematic diagram shows layout of low purity oxygen storage and control at Inland Steel Co.



eral service system. As the lines were extended to other scarfing facilities, it was convenient to tap the line for other uses, mainly for cutting and welding, which alone would not justify the extension of these lines. As the distribution system grew, the price of oxygen was reduced which made possible the justification for further extension. The pipeline distribution system has not eliminated the need for compressed oxygen cylinders; however, the relative quantities of oxygen used in this form has steadily decreased. This has been an important advantage from the standpoint of both cost and labor requirements for handling cylinders.

In 1958 we shall discontinue receiving low purity and receive only high purity oxygen. This will not change the usage, as high purity oxygen will then be used for the same purpose for which low purity is now used. Except possibly for alteration of the incoming pipeline arrangement for metering purposes, we do not at this time intend to make any changes in the distribution systems. With this new arrangement, all of the oxygen will go to the surge tanks, thus eliminating the variation in flow, which now is present on the incoming high purity line. The change to all high purity is being made because it is the most economical method of satisfying our increasing high purity oxygen requirements and not because of any dissatisfaction with the use of low purity nor because of any expected gain by using high purity oxygen in the open hearths.

WHY THE PIPELINE METHOD OF SUPPLY WAS SELECTED

Why did Inland choose the pipeline method of supply rather than buying or leasing an oxygen plant?

As has been mentioned previously, during the course of the open hearth tests, it had been established that the open hearth oxygen requirements were in the neighborhood of 200 tons a day. From our tests, from published results and from consultation with other steel producers, it was concluded that it would be most economical to use 95 per cent oxygen in the furnaces since this could be obtained at a lower price than high purity.

Three basic plans of supply were carefully considered along with several variations of each plan. The basic plans were:

1. Purchasing, installing and operating our own plant.
2. Purchasing oxygen from a supplier's plant located on our property.
3. Purchasing oxygen delivered by pipeline from a supplier's plant located off our property.

Table I shows an analysis made in 1951 of the cost of oxygen from each of the first two types of supply. Notice that we calculated these costs at both 4500 and 3000 tons per month. We also calculated the cost at full load or 6000 tons per month, arriving at a cost per ton of approximately $12. This figure, of course, is relatively meaningless because no plant could be expected to operate at full load month after month.

It is realized that the costs shown on this estimate are somewhat higher than those seen published in literature; however, published figures do not usually include the cost of site clearing and preparation, extension of water, sewer, steam and power lines, etc. All of these items can

TABLE I

Analysis of Oxygen Costs per Month (Summary of Analysis Prepared in 1951); Plant Capacity 200 Tons per Day

	Case I		Case II	
	Inland-owned plant		Supplier plant at Inland	
	4500 Tons	3000 Tons	4500 Tons	3000 Tons
Oxygen	...	...	$63,360	$57,860
Power				
Oxygen plant	$18,000	$13,100	...	...
Compressors	4,450	3,240	4,450	3,240
Maintenance	6,400	6,400	2,400	2,400
Labor				
Oxygen plant	1,475	1,475	...	...
Compressors	1,475	1,475	1,475	1,475
Investment cost (10 per cent amortization, 2 per cent taxes and insurance)	32,300	32,300	12,300	12,300
Miscellaneous	3,000	3,000	1,000	1,000
Total costs	$67,100	$60,990	$84,985	$78,275
Cost per ton	14.91	20.33	18.89	26.09
Saving (Case I over Case II)	$17,885	$17,285		
Profit after taxes (federal only)	8,585	8,300		
Additional investment	$2,000,000	$2,000,000		
Return on investment, per cent	5.2	5.0		

be quite expensive and also vary considerably with location. Furthermore, most published oxygen cost figures are based on lower power costs than were used in our estimates. We feel that since our immediate expansion in power requirements would have to be purchased from the local utility at somewhat more than $0.01 per kwhr, it was realistic to use this figure for our estimate.

From this analysis it can be seen that there was little promise that there would be an adequate return on capital investment if we were to purchase and operate our own plant.

Although we do not wish to give full details of the proposal for the case III method of supply, purchasing oxygen delivered by pipeline from a supplier's plant off our property, we can say that it was the most attractive of the three. One significant reason for this was that our supplier already had a large producing plant within a relatively short distance from our mill. Therefore, this was the one that we chose for obtaining our oxygen supply.

Aside from cost there are several other advantages to receiving oxygen by pipeline. Some of these advantages are:

1. Land—The Indiana Harbor Works is largely built on land reclaimed from Lake Michigan; for this reason it is somewhat more difficult to provide space for new facilities than might ordinarily be expected. It is difficult to place a specific value on land acquired by filling in the lake, but there is a limit to the extent that new land can be acquired in this manner and unless there is a clear economic justification otherwise, it is advantageous to reserve the land for facilities which must be physically closely associated with steel production.

2. Continuity of Operation—On the whole there is very little to get out of order in a pipeline. Any time the unit which serves us must be shut down for repairs, our supplier is able to meet our oxygen requirements from his already existing network of mass plants for liquid

production and distribution. For us to have obtained this same over-all protection, from a plant of our own, would have greatly increased the capital investment required.

3. Personnel—With most processes there are problems which can best be handled by experienced personnel and certainly the manufacturing of oxygen is no exception. By receiving oxygen by pipeline, Inland was relieved of the problems and expense of hiring and training of new personnel and received the advantage of having their oxygen supply problems in the hands of men with years of experience in the oxygen process.

What has been our experience with this supply arrangement? The low purity unit which supplies Inland has operated 96.5 per cent of the time since it was first placed in operation. The downtime has been about equally divided between scheduled and unscheduled shutdowns. Excluding the first year, the unit has operated over 98 per cent of the time. At all times when the tonnage unit was shut down, the supply and consumption of high purity oxygen was normal. High purity oxygen was also available and was used at the open hearth furnaces; however, because of the higher rate charged for high purity, Inland usually chose to use oxygen for the furnaces at something less than the normal rate, generally restricting its use to decarburization.

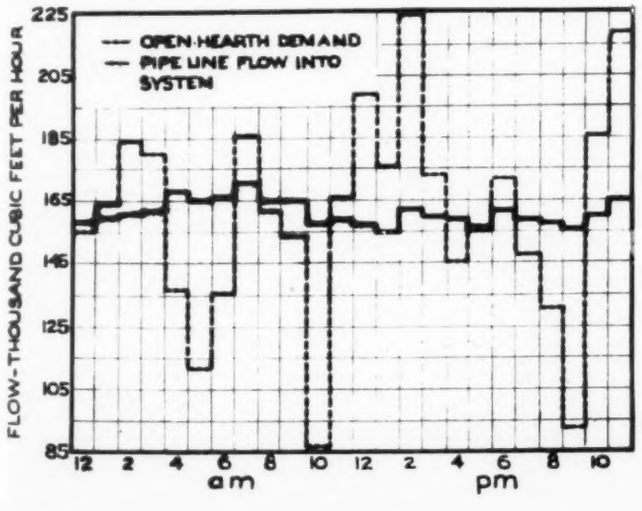
The average demand rate since the tonnage unit was started has been 81 per cent which is only slightly higher than the 75 per cent upon which our cost estimates and comparisons were originally based.

Figure 4 shows the hourly low purity oxygen demand for a typical day. The solid line represents the rate of oxygen delivery. This figure demonstrates the effectiveness of our storage tanks in meeting the varying open hearth demand while receiving oxygen at a fairly steady rate.

Figure 5 shows the daily total oxygen demand fluctuations for a typical month. This type of curve would be useful in determining the size tonnage plant required to supply our needs and in predicting the average load factor at which it could be expected to operate. Our past experience in meeting this varying demand has been quite simple—as simple as opening and closing a valve.

The tonnage agreement of 1951 enabled Inland to make a substantial saving in the cost of oxygen for open

Figure 4 — Hourly low purity demand shows marked variations on a typical day.



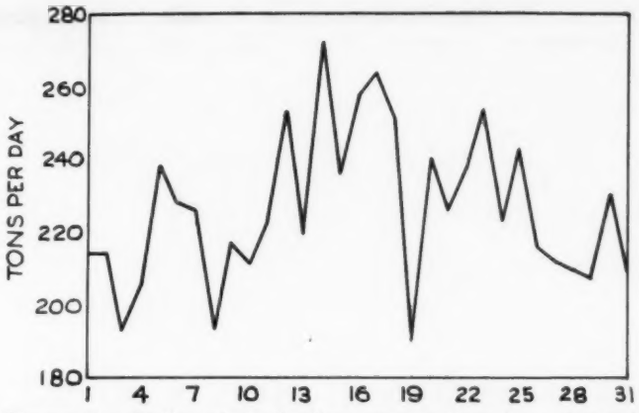


Figure 5 — Daily total pipeline oxygen flow in a typical month also varies markedly.

hearth use and for a portion of the oxygen for scarfing and general purpose uses. The open hearth requirements have remained about the same as they were when the tonnage agreement was made; however, requirements for high purity oxygen increased from about 20 tons per day in 1951 to 70 tons per day by the end of 1956. Because of the increased usage and the higher price, the cost of high purity oxygen had become an increasingly significant proportion of the total oxygen costs. It was known that improvements had been made in tonnage plants which made it possible to manufacture high purity oxygen for approximately the same cost as for low purity. In 1956 a new study was made of the cost of manufacturing our own oxygen, based upon supplying the total requirements with high purity. Because of increased capacity and elimination of the requirements for a two-purity storage arrangement, the estimated cost of oxygen from an Inland owned plant was lower than in 1951.

Our supplier was requested to submit a proposal to meet Inland's expanded oxygen requirements. A proposal was submitted which was based on modifying their tonnage unit to produce high purity only and to increase its capacity by 35 per cent. Under this proposal, up to 270 tons per day of high purity oxygen would be delivered for less than the current tonnage price.

When the estimated cost from an Inland-owned plant was compared to the supplier's proposal it was concluded that the prospect of return on the capital investment required to construct an oxygen plant was inadequate to justify the expenditure. The weight in favor of this decision was increased by the other advantages of the pipeline arrangement which have already been enumerated. In February of this year a revised contract was signed with the supplier based upon their proposal. Deliveries of high purity oxygen under the terms of this agreement are expected to commence in 1958.

THE FUTURE OF OXYGEN UTILIZATION

What do we think of the future of oxygen in the steel industry in general and at Inland in particular? The use of oxygen in the steel industry in the future will undoubtedly increase, the extent of this increase will depend upon the availability of low cost oxygen and the advancement of the technology of its application. The cost of oxygen has been reduced in the past few years by improvements in process equipment and increasing

plant size, possibly other improvements can be made which will further reduce oxygen costs and enhance the future of its usage.

Most of the oxygen used in the steel industry today has been applied to increase the capacity of existing production units: blast furnaces, open hearths and bessemer converters. The possibilities for utilization of low cost oxygen in this field are very large compared to the present rates of consumption. For instance, claims have been made of economical enrichment of air for blast furnaces of up to 3 per cent oxygen; application of this amount to Inland's furnaces would require more than 1000 tons per day.

New processes have been developed for which the use of oxygen is an integral part, such as the oxygen converter which requires about one ton for each ten tons of steel produced. This process has gained wide acceptance and present indications are that it will be applied to a larger extent in the future.

Processes are being developed for the reduction of iron ore which require the use of oxygen. For example, the production of sponge iron by reducing ore with hydrogen manufactured by partial combustion of natural gas with oxygen. This process requires about one ton of oxygen for each five tons of iron produced. Some publicity has also been given to an experimental process for the direct manufacture of steel from iron ore by the use of oxygen for partial combustion of coal which furnishes both heat and reducing agent. These or other processes will probably find a place in the steel industry, and could be very important to manufacturers of oxygen equipment, oxygen suppliers and to the steel industry.

As for the immediate future for oxygen at Inland, the present supply arrangements are considered adequate for the next two or three years. Consideration is now being given to the experimental use of oxygen for blast furnace blast enrichment. The oxygen for this experiment is to be furnished by our supplier from the tonnage plant. Excess oxygen above the capacity of the tonnage plant will be furnished from their liquid facilities and delivered by the existing pipelines.

For the more distant future we expect that our oxygen requirements will grow both because of increased steel production and improvements in process technology. The method of supplying the increased requirements, whether by an Inland owned plant or by a supplier, will be decided when the requirements are known. The selection will be based upon an engineering study of the conditions existing at that time.

The manufacture of oxygen can, under some circumstances, be a profitable venture for a steel manufacturer and in others it can be more practical to purchase oxygen from an on-site or off-site supplier's plant. Some of the more important factors which would influence the decision would be: availability of excess by-product fuels, steam and/or power generating capacity, cost of purchased power, quantity of oxygen required, availability of land and water resources, degree of protection required for continuity of operations, and availability of capital. So far as the author is concerned, there is no rule that will fit all oxygen consumers or any consumers at all times, but each must make his own choice based on his particular set of circumstances.

In conclusion, the use of oxygen has enabled Inland to improve quality, to increase productivity of open hearth furnaces and to reduce man-hour requirements for surface conditioning, scrap preparation and maintenance activities. By purchasing oxygen, we have been able to secure large quantities for experimental use and later for regular production use without capital expenditures for oxygen production facilities. The continuity of supply has been excellent, and oxygen for increased demands has always been available. We are well satisfied with our present supply arrangements.

"ECONOMICS OF GENERATED VS PURCHASED O_2 FOR STEEL PLANT USE"

by R. A. LAMBERT, Superintendent,
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THE use of oxygen gas in steel plants has become recognized as a utility of prime need which can now be classed in the same vital category as compressed air, steam, water and electric power. For the past two decades, oxygen consumption at the Pittsburgh Works of Jones & Laughlin Steel Corp. has steadily increased as it has in other such fully integrated steel plants. In 1938 oxygen consumption rate averaged 115 cu ft per net ton of ingots produced. In 1956 we used 250 cu ft of oxygen for each ingot ton produced. Both years were at 100 per cent ingot operating rate and exclude any use of oxygen for combustion in open hearth furnaces. Oxygen use in the open hearth shops has also greatly increased over these years. Most shops in the country use this utility to oxidize the carbon from the steel bath, supplementing or replacing feed ores; it is also used to increase the open hearth bath temperature and to shape up the bath slags.

In the past few years, considerable attention has been directed toward the use of oxygen to support combustion and thereby increase fuel input into the open hearth furnaces. Purpose of such use is twofold; for raising flame temperature to accelerate meltdown, and to permit increase in fuel input in underdrafted furnaces by reduction of total waste gas quantities. Oxygen injection through roof lances into the open hearth furnace is being utilized to increase productivity. Increased iron tonnage from oxygen enrichment of blast furnace wind is another appreciable contribution of this utility to steel plant operations. Five steel plants in the western hemisphere have installed, or are in process of installing, the basic oxygen process. In certain open hearth shops experiments are being conducted using oxygen only with no conventional fuel use at all. The only heat source is supplied from the hot metal charge.

This paper, however, is confined to high purity oxygen for normal steel plant uses at the Pittsburgh Works. It is recognized that low purity oxygen has application, particularly in open hearths and blast furnaces and that such low purity "on site" generation is less costly than high purity production. For reason of flexibility and to minimize the pipe distribution system, we decided for the 100 per cent high purity "on site" generation for the extent of our present needs.

It was only natural that with growing uses of oxygen over the years, the plant operators would consider the

possibilities of more economical procurement. There was little question but that oxygen generated "on site" should be appreciably less expensive since oxygen transportation and handling expense would disappear. The Pittsburgh Works total oxygen consumption, after a new slab hot scarfer installation, was expected to approximate upwards of 72,000,000 cu ft per month at 100 per cent operating rate. The consumption of this oxygen was directed to our open hearth furnaces for decarburization, use on a bloom and slab mechanical hot scarfer, hand scarfing for steel conditioning and for an appreciable amount of miscellaneous cutting, welding and burning, including scrap recovery, skull and button burning and miscellaneous use on open hearths and blast furnaces.

Before the installation of the "on site" oxygen generating plant, a separate liquid oxygen vaporizing plant was located on each side of the Monongahela River, since the Pittsburgh Works straddles the river. The South Side vaporizing plant supplied the open hearth furnaces, the billet scarfing machine, hand scarfing for billet and slab conditioning and miscellaneous uses for the South Side. The North Side liquid oxygen vaporizing plant supplied miscellaneous scrap burning; at times some limited slab conditioning; conventional miscellaneous use at blast furnaces, bar mills, coke works and strip mill area. From both the North Side and the South Side vaporizing plants, pipe transmission lines extended the entire plant area except that they were not interconnected, each river side of the plant area being supplied from its separate source. Bottled oxygen in the plant averages less than 0.1 per cent of the total oxygen consumed. The works averages 350 oxygen cylinders per month.

Consideration was given to replacing the existing supply source with an "on site" plant which would satisfy our then known demands plus the mechanical slab hot scarfer. The Pittsburgh Works Division has a rated annual capacity of 3,300,000 net tons of ingots and 1,900,000 net tons of iron. This activity, with completely integrated rolling equipment for hot and cold rolled bar and strip, is confined in an area of 295 acres. This plant is just about the most crowded in the country for its production capacity and every square foot of ground area is at a premium. Therefore, the selection of proper area for the generating plant site was a problem. It is rather unfortunate that space was not available in proximity of the strip mill annealing furnaces so that use could have been made of the wasted nitrogen. Geographically, this was not feasible for reasonable investment costs. When the decision was made to install an "on site" generating source, it was only necessary to interconnect the North and South Side main transmission lines and install a single 8-in. line from the new site to the existing lines; this distance was relatively short. The Pittsburgh Works plant bridge interconnects the North and South Side for transportation purposes, including the movements of hot metal from the blast furnaces to the open hearth mixers. The interconnecting oxygen transmission line over this bridge tied both sides of the river together so that oxygen could be supplied from a single source.

Figure 1 shows the oxygen plant in just about the only area that was available to satisfactorily fulfill the conditions. Location is at the south end of the plant bridge.

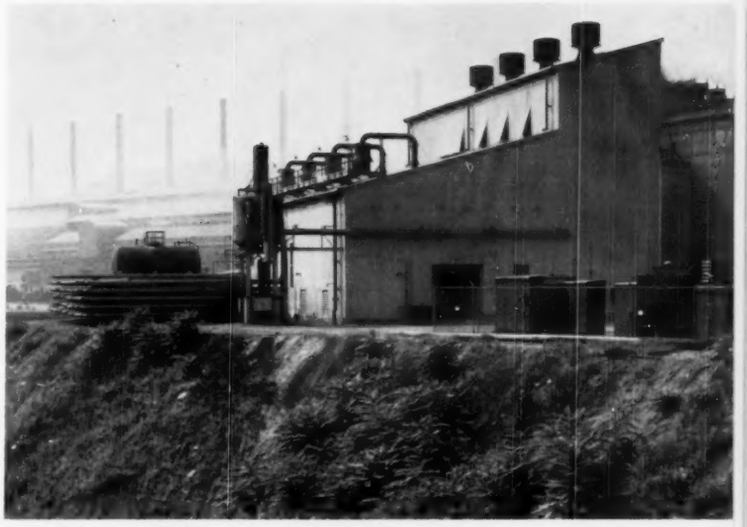
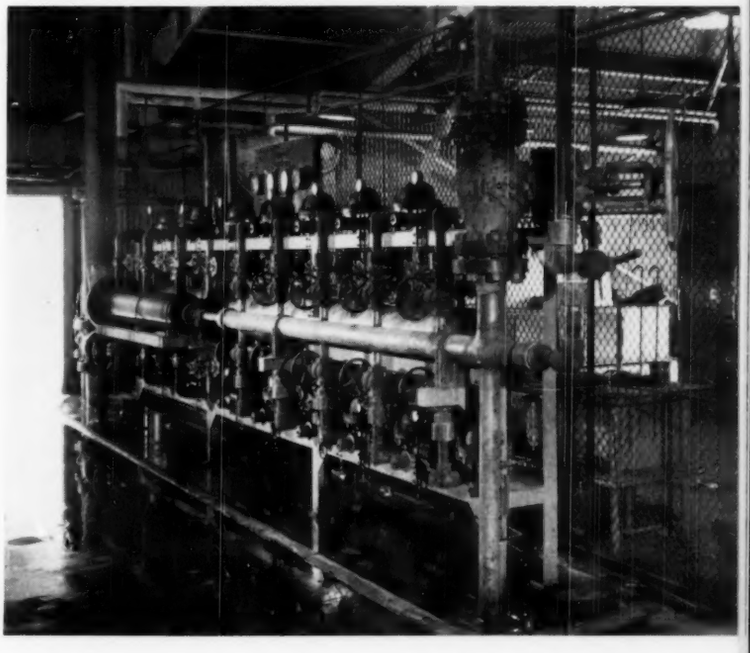


Figure 1 — Finding a suitable location for the oxygen plant was quite difficult.

In the foreground is the south river bank. In the background are the stacks of the No. 4 open hearth shop. Note the four exhaust stacks from the building for nitrogen expulsion. To the left is the gaseous oxygen storage bank. There are 250 cylinders, 10.6 in. internal diameter, varying in length from 35 to 43 ft. The total volumetric capacity is 6333 cu ft. The bank will hold 1,000,000 cu ft of oxygen at standard conditions. Provisions are made for augmenting this storage simply by adding additional cylinder banks, should we ever decide to do so. Pressure relief valves are set for 2250 psig. For all practical purposes, with a plant line pressure to the consumers of 150 psig, the reserve storage capacity available for use is 900,000 cu ft at standard conditions.

Figure 2 is a view of the pressure reducing stations for reducing the high pressure to plant flow conditions. The high pressure line in the foreground is followed by ten pressure reducing stations which are all paralleled to reduce the pressure to 250 psig. Oxygen at this pressure

Figure 2 — This station is used to reduce high pressure oxygen to plant flow conditions.



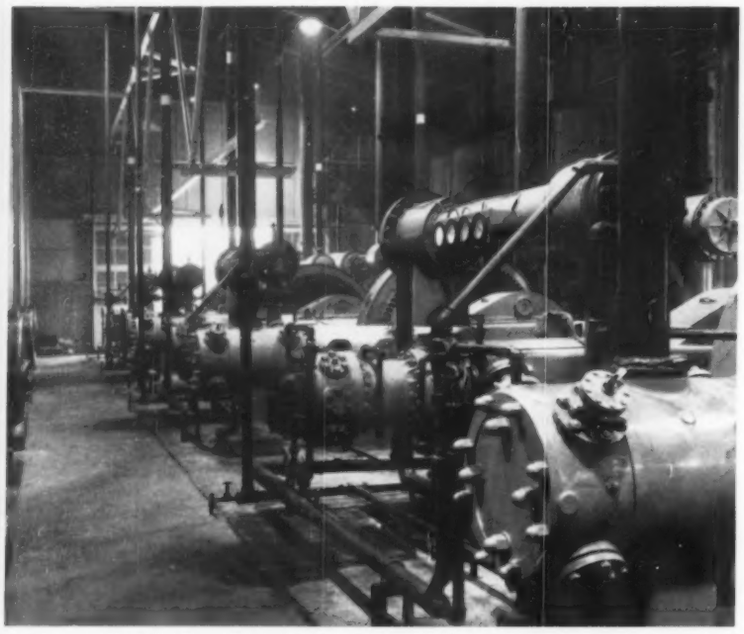


Figure 3 — Four 4-stage machines are used for compressing air going into fractionating towers.

then flows through the six additional paralleled pressure reducing stations to the delivery line conditions of 150 psig. This is the plant pressure leaving the oxygen plant.

Figure 3 illustrates the four 4-stage machines for compressing the air before delivery into the fractionating towers.

Figure 4 is a close-up of a single 4-stage compressor unit. A 900-hp, 60-cycle motor drives each compressor.

Figure 5 is a view of the aisle-way of the four generating units. Each unit rates at 25 tons of oxygen per day. The four units have a total rated production of 100,000 cu ft of oxygen per hour. On a 30-day month, this equates to 72,000,000 cu ft. We have obtained as high as 76,000,000 cu ft in a 30-day period with cool weather conditions and no machine outages.

This plant is operated by two men per turn who perform the attendance and do minor maintenance work. Repairs in excess of minor maintenance are serviced from the South Side boiler house repair group which is in proximity to the oxygen plant. There has been no increase to the boiler house repair force for handling oxygen plant repairs. Also, no increase in supervisory personnel was necessary.

Table I indicates the oxygen consumption of major plant areas on a percentage basis. Plant miscellaneous uses account for 28 per cent of the total used, with an average monthly variation of 3 per cent. Total scarfing demands account for 34 per cent and the monthly variation in this demand is about 5 per cent of total plant use. Open hearth decarburization use varies more than any other plant use. With an average of 32 per cent the month-to-month variation at 100 per cent ingot operating rate is 9 per cent. For the total plant usage, the variation indicates from 86 to 113 per cent of average consumption. All such variations obviously do not occur simultaneously for any long period. Several days of peak usage without unlimited supply of liquid oxygen would be a concern. Note that slab mechanical scarfing usage has a range of 14 to 16 per cent of the total usage. This range spread is much less than we expected.

During the time that the oxygen plant installation was being planned, it was necessary to decide for the minimum storage capacity with the maximum assurance of continued oxygen supply during any normal outage of a single oxygen unit and during peak demand consumption periods. Estimation in respect to peak demand period was necessary because the new slab scarfing machine was not in operation at the time. Numerous types of peak load demand charts and related data were developed, and we spent considerable time to determine the effects of simultaneous demands of the various consumers plus time duration of these peaks. In addition, estimated demands from the mechanical scarfer were necessary as well as an estimate of what scarfed tonnage would be. Some estimated that even a 10,000,000 cu ft gaseous storage would not suffice with such "on site"

Figure 4 — A 900-hp, 60-cycle motor drives each 4-stage compressor unit.

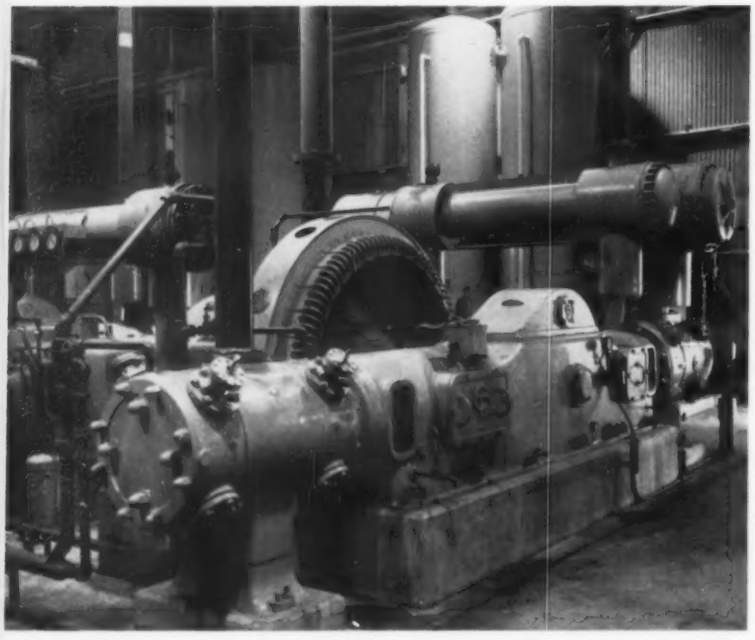


Figure 5 — Each generation unit is rated at 25 tons of oxygen a day.

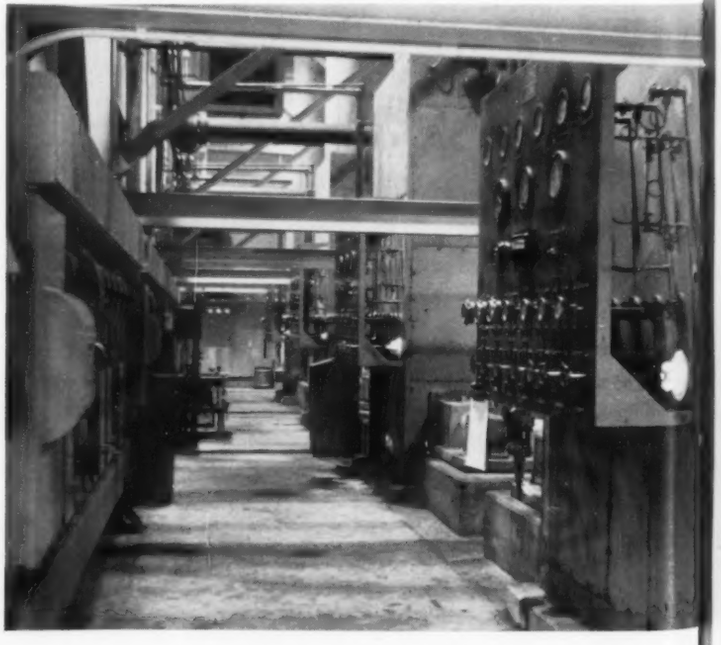


TABLE I
Plant Oxygen Distribution at 100 Per Cent Ingot Operating Rate Based on 3 Month Average

	3 Month average, per cent	Range per month, per cent
Open hearth decarburization		
No. 4 shop (11 furnaces)	17	15 to 18
No. 2-A shop (4 furnaces)	7	6 to 8
No. 2-B & 3 shop (6 furnaces)	8	7 to 11
Total	32	28 to 37
Scarfing		
Bloom mechanical scarfing	8	7 to 8
Slab mechanical scarfing	16	14 to 16
Hand scarfing	10	9 to 11
Total	34	30 to 35
Miscellaneous uses	28	26 to 29
Open hearth combustion	6	2 to 12
Total	100	86 to 113

generation with no liquid oxygen backup. However, decision was eventually made for the 900,000 cu ft gaseous storage. To date, we have found that selection for this capacity has served very satisfactorily. Calculations relative to the peak demand loads of the slab scarfer were higher than the theoretical figures, but fortunately the total scarfed tonnage through the machine has averaged less.

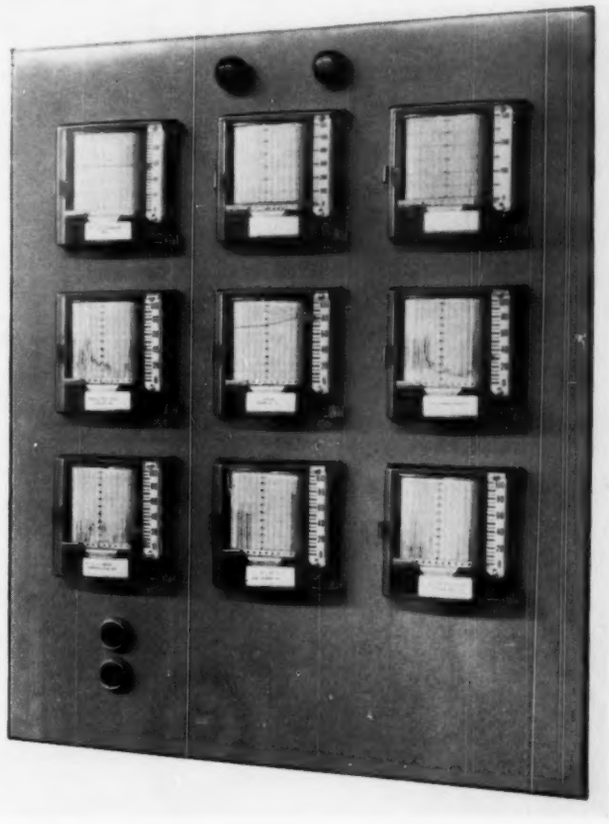
The selection for four unit generation, rather than a lesser number of higher capacity units, was made primarily for flexibility in operation. However, when the four units were decided upon, No. 2-B open hearth shop was not operating nor was there any apparent indication of early operation. This shop comprises five old open hearth furnaces of the tilting design. Before the oxygen plant installation was completed, and before the mechanical scarfer installation was completed, contrary to our expectations, these marginal open hearth furnaces were lighted. This indicated that additional units might be required if our original expectations as to total slab scarfing consumption were verified by actual practice. Increased ingot making not only requires the oxygen for decarburization in the open hearth, but throughout the plant with the increased activity level, oxygen consumption increases. When the plant site was planned, space provision was made for installation of two additional similarly sized units or for a single larger unit. This was to allow for future increase in normal demands. We have, therefore, made recommendations to augment the present oxygen plant to assure for No. 2-B open hearth shop needs and for any increase in scarfing use. This will provide us with continuous oxygen supply without any curtailment necessary during plant outage for defrosting and permit some additional oxygen use in open hearth furnaces for combustion purposes or for any other experimental use of oxygen.

A related step to selecting the reserve capacity was to control this reserve so that in case of heavy demands for continuous turns of mechanical slab scarfing or unexpected unit outage, the storage would not be bled dry. It was recognized that some means of continuous oxygen dispatching was necessary. We had in the plant, on a continuous basis, the dispatching function for plant fuels such as coke oven gas, natural gas, tar and oil, railroad and barge transportation dispatching, etc., to the various consuming points. The oxygen dispatching duty was added to the existing occupation and no increased costs resulted from the oxygen dispatching on a 24 hour, 7 day/week basis.

It was necessary to transmit to the dispatcher's office the record of the oxygen situation at any given time. Figure 6 illustrates the oxygen panelboard located in the dispatcher's office. At the top left, the strip recording represents the plant line pressure of 150 psig. The middle row, first instrument to the left, is South Side downriver service from the oxygen plant with a 4-in. service line. This includes billet scarfing, No. 2-A and 2-B open hearth use and all other miscellaneous use throughout this area. The middle instrument in the middle row is record of oxygen storage in terms of cubic feet at standard conditions. The middle row instrument to the right is the total oxygen consumption for the plant. The primary orifice element is located on the main 8-in. line from the generating plant. In the bottom row, the left end instrument is No. 4 open hearth oxygen use for decarburization and combustion when used. This line is sized at 8-in. diameter. The bottom row, middle instrument, records the slab mechanical scarfing only. The slab scarfer is served with an independent 8-in. line which has sufficient length to obviate need for a surge tank. The last record is No. 4 open hearth miscellaneous use which serves this shop through a 4-in. diameter line. The remaining 3-in. interconnecting line over the plant bridge is metered, but we did not find it necessary to record this flow on the dispatcher's panel. Thus, we have two 8-in., two 4-in. and one 3-in. lines as main distribution lines from the generating plant.

These smaller type strip recording instruments occupy very little space in the gas dispatching office, yet suffice the need. Transmission of all these records from

Figure 6 — Units on panelboard are mounted for convenient operation.



the various field locations to the office is with use of a single pair of plant telephone wires. Transmission frequency is in the audio-range. This application is relatively inexpensive and serves excellently. The dispatcher receives daily the anticipated operation of the various mills, particularly the slab scarfer. The dispatcher contacts the oxygen plant operator as necessary for a check on any pertinent information such as contemplated outage on any unit for defrosting or otherwise. The dispatcher has all information to take any action to avoid a serious oxygen shortage from developing from any unusual conditions.

Figure 7 is the reproduction of three recordings from the panelboard. The top chart is the total flow to the consumers. The middle record is of the same time period for the reserve storage situation. The bottom record represents the slab scarfer oxygen consumption. Obviously, total consumption is, at times, much higher than the oxygen plant production of 100,000 cfhr. A horizontal line at 33 per cent would represent the oxygen average production. At the periods of consumptions above production, the storage reserve falls off. This is evidenced on the middle chart record. Note that when the slab scarfer ceases operation, which in this instance was about 9:00 PM, the reserve storage commenced increasing. The scale readings on the storage chart will indicate that minimum during this period was 610,000 cu ft and maximum was 810,000 cu ft. Note the instantaneous peak demands of the slab scarfer operation. Maximum indicates as high as 300,000 cfhr rate for the instantaneous peak. Also, note that for periods the scarfing operation ceases during the operating turn. In fact, the number of slabs scarfed can be counted by the vertical lines shown.

It is recognized that if a plant severs use of liquid oxygen shipments and is completely dependent on "on site" generation, then the oxygen reserve capacity becomes a very important factor which, if miscalculated

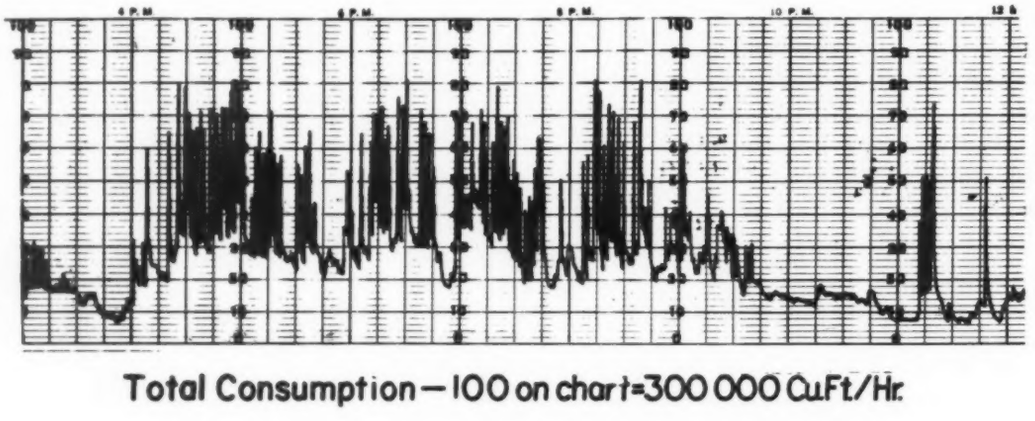

Total Consumption—100 on chart=300 000 Cu.Ft./Hr.
Storage—100 on chart= 1.0 million Cu.Ft.
Slab Scarfer Consumption—100 on chart=300 000 Cu.Ft./Hr.

Figure 7 — Recording chart gives complete data needed for operation.

or not handled properly, could conceivably result in extremely serious consequences if the reserve is permitted to disappear. Obviously, this would not only affect production units such as open hearths and mechanical scarfers, but for the entire plant appreciable delay for miscellaneous welding, cutting and burning operations would result.

During the early part of this year we experienced some excellent training in the dispatching of plant oxygen. One of the major suppliers of liquid delivered oxygen was on plant curtailment due to a work stoppage. Our management decided that the Pittsburgh Works transport gaseous oxygen, by truck, to the Aliquippa Steel plant, about 20 miles distant. Deliveries averaged 600,000 cu ft per 24-hr day or about 25 per cent of the Pittsburgh total oxygen plant production. With this reduction in available supply to Pittsburgh plant operations, frequent curtailment of oxygen for open hearth use was necessary. Recall that Table I shown previously indicates 32 per cent use to the open hearth for decarburization. With 25 per cent of our production going to Aliquippa, we did not have too much left for the open hearths. The dispatching procedure was such that during this 75-day period, we never had to curtail any scarfing operations or did we have any miscellaneous use curtailment or delays. We were able to maintain satisfactory reserve storage to provide for all peak load demands of the slab scarfing operation.

In considering the economic factors involved for "on site" oxygen generation with gaseous storage backup, we found this method to be most attractive. Expenses for the building erection and provision for utilities, particularly water and electric power, were borne by Jones & Laughlin. The generating equipment proper was purchased on a lease arrangement with a fixed monthly charge for 15 years. At expiration of the lease arrangement, ownership of the generating equipment is acquired by J. & L.

Table II is a record of our "on site" operating costs at various ingot operating levels. For the 100 per cent plant ingot operating level, note that operating and maintenance labor, supplies and materials account for about 17 per cent of the total costs. The lease costs account for 44 per cent of the total expense. Utilities, primarily electric power, account for 38 per cent. Electric power consumption averages 32.2 kwhr per 1000 cu ft of oxygen generated. This, of course, includes a straight average monthly production. Service water consumption averages 529 gal per 1000 cu ft and city water consumption averages 4 gal per 1000 cu ft. After fifteen years' operations, one and a half years have already gone by, the generating costs will be reduced approximately 50 per cent due to disappearance of the lease charge. Fifteen years may seem to be a long time. However, from an equipment replacement viewpoint, a fifteen year old machine still has a very useful life expectance, particularly in the steel industry.

TABLE II
"On Site" Oxygen Operating Expense

Ingot operating level, per cent	100	80	70	50
Oxygen consumption—1000 cu ft	67,530	52,390	43,375	30,690
Operating cost, including lease charges	$58,700	$54,000	$50,800	$44,900
Unit cost per 1000 cu ft	$ 0.869	$ 1.031	$ 1.171	$ 1.463
Operating cost details, per cent				
(a) Operating labor	6.7	7.2	7.7	8.7
(b) Maintenance labor, material and supplies	10.2	9.8	7.5	6.0
(c) Technical services	0.7	0.6	0.6	0.7
(d) Utilities	38.2	34.2	33.1	26.8
(e) Lease costs	44.2	48.2	51.1	57.8
Total	100.0	100.0	100.0	100.0

Oxygen consumption of 67,500,000 cu ft per month is indicated for 100 per cent ingot operating rate. This is an actual average usage on a month to month basis, excluding any oxygen for open hearth combustion use. Observe that it costs $58,700 to produce this quantity or at a unit cost of 8.7¢ per 100 cu ft. At very low operations this unit cost will rise. At 70 per cent ingot operating rate, we would expect this unit cost to approximate 11.7¢ per 100 cu ft of oxygen produced, unless we find profitable uses for our excess capacity. Increment cost of such oxygen would approximate the utility power and water costs, about 3.3¢ per 100 cu ft of oxygen.

At the reduced production levels, the four-unit plant has the flexibility to reduce power consumption by removing units from operation for the reduced demand periods. Remember that electric power constituted the largest single operating expense after lease charges.

Summarizing, it can be said that the Pittsburgh Works Division is well satisfied with the method in which we have reduced the cost of this utility. If the same, or comparative, installation and operating costs, existed today, with similar comparison of operating advantages and disadvantages in the method of plant oxygen procurement, we would have followed the same course—namely, the installation of a multiple-unit, high purity oxygen generating plant with gaseous storage.

"OPERATION AND MAINTENANCE OF A 100-TON DOUBLE-CYCLE, GASEOUS O_2 PLANT

by G. T. WRIGHT
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Dominion Foundries and Steel, Ltd.
Hamilton, Ontario, Canada

IN 1954, Dominion Foundries & Steel, Ltd., in Hamilton, Canada, installed the first oxygen steelmaking equipment on this continent. This process depends on reliable and economical production in large volumes of high purity oxygen. This paper describes the operation and maintenance of one of the 100-ton, double-cycle, gaseous oxygen plants, which supply oxygen for the steel melt shop and other miscellaneous uses.

Figure 1 is a flow sheet of the No. 1 oxygen plant at Dominion Foundries & Steel. There are two plants, each rated at 100 tons of 99.5 per cent oxygen per day.

All the air comes into the plant through a dry paper filter to a 2000-hp, 8700-rpm electrically driven turbocompressor which compresses 9600 cfm of air to 65 psig. It is then water scrubbed and passed through a separa-

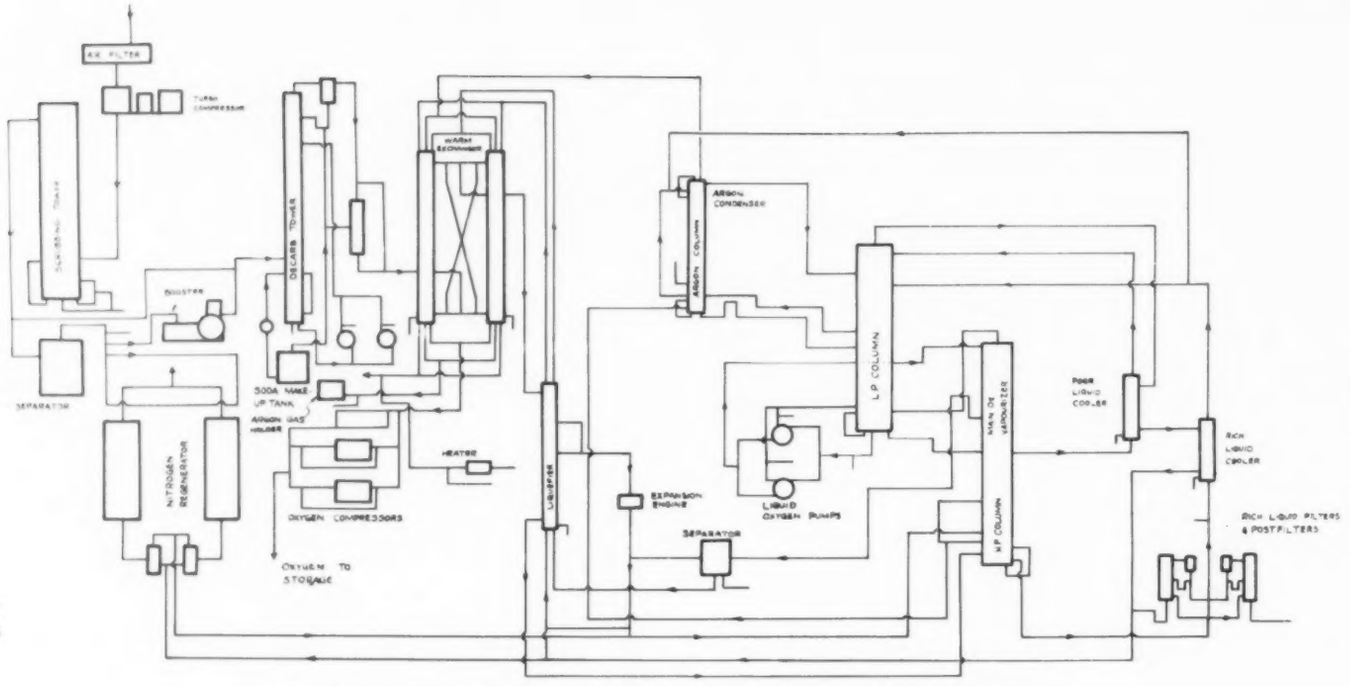


Figure 1 — Flow sheet of oxygen plant at Dominion Foundry and Steel.

tor to remove any entrained solids or water soluble impurites. At this point, 30 per cent of the air stream is taken off to go through the high pressure circuit and 70 per cent carries on through the low pressure circuit.

The low pressure air is cooled in the regenerator to −245 F. There are two regenerators, each being a steel shell 4 ft-6 in. diam x 15 ft-6 in. high, filled with 140 corrugated aluminum pancakes. On the incoming side, one regenerator is cooling the air while the other regenerator is being cooled by the outgoing cold nitrogen.

The regenerators are reversed every 120 sec, preventing either from warming up. The regenerator removes any trace of carbon dioxide or moisture which freezes on the regenerator pancakes and is blown out by the waste nitrogen stream when the regenerator reverses.

From the regenerator, cold high pressure air goes to the high pressure column where it contacts the tubes in the vaporizor. The high pressure column is 34 ft high and 5 ft 2 in. in diameter and contains 20 trays as well as the vaporizer tubes. The air is liquefied here and falls to the bottom of the column. Rectification starts at this point and this liquid has 40 per cent oxygen. The differential pressure forces the liquid through the filter where the acetylene is removed, and through a cooler into the low pressure column. The low pressure column is 28 ft 6 in. high and 63 in. in diameter and has 57 copper trays. The rich liquid falling over the trays passes counterflow to the nitrogen rising in the low pressure column. The pressure in the low pressure column is maintained at 3 to 4 psig by controlling the nitrogen outlet valve. After the rich liquid has fallen to the bottom of the low pressure column, it is pumped to the vaporizer section of the high pressure column by two centrifugal liquid oxygen pumps. Some 90 per cent of the gaseous nitrogen at −280 F goes through the cooler and subcooler in the low pressure circuit and leaves the plant through the regenerators. Gaseous oxygen and some nitrogen and argon flow out through the liquefier and exchanger to cool the high pressure circuit.

The high pressure circuit provides refrigeration to make up for the heat leakage from the cold box. This is provided by 30 per cent of the air stream which is taken from the turbo blower discharge. The air is boosted to 350 psig and stripped of carbon-dioxide in the caustic tower and then dried. It is further cooled in the exchanger and liquefier by passing counterflow to the oxygen leaving the vaporizer. This cold air is then expanded through the expansion engine to −250 F and 65 psig and then goes to the high pressure column where it rejoins the main air stream and is liquefied.

All the cold is used to chill the incoming air so the oxygen and waste nitrogen are delivered at approximately atmospheric temperature and pressure which improves the efficiency of this column. After the oxygen leaves the plant, it is compressed to 300 psig by piston compressors for use in the steelmaking division. Four storage tanks provide 155,000 cu ft of oxygen between 300 psig and 200 psig.

All the pressure vessels are fabricated from stainless steel to prevent corrosion and to minimize the effect of low temperature. Copper is used in the trays and heat exchanger tubes.

The high and low pressure columns, the liquefier, the nitrogen regenerators, the warm and cold exchangers are in a steel box packed with rock wool to reduce heat leakage. This is called the cold box.

Figure 2 shows the control panel of the plant and the regenerators.

In the operation of the plant the purity is controlled by the oxygen outlet valve which changes the back pressure on the column thus controlling the rectification. The refrigeration cycle is controlled by changing the speed of the expansion engine, the setting of the valve cams. Booster pressure is varied to maintain the liquid at a uniform level in the low pressure column.

Readings are taken and recorded hourly on all the temperatures and pressures through the system so that any change is noticed immediately.

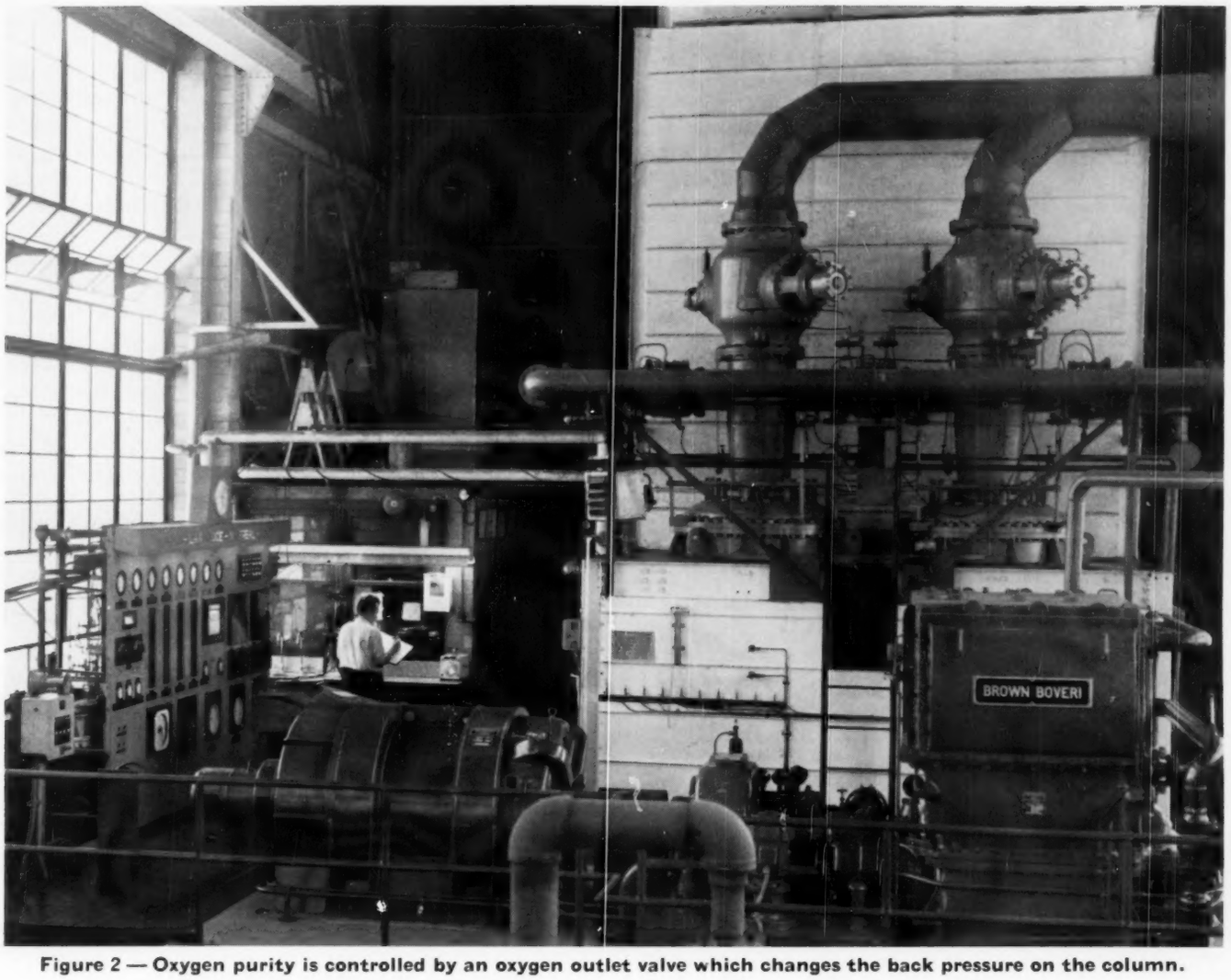


Figure 2 — Oxygen purity is controlled by an oxygen outlet valve which changes the back pressure on the column.

Tests are run hourly for oxygen purity and nitrogen purity. A close check is kept on the liquid all through the plant for traces of acetylene. One test is done by the operators and a second test is run by the general laboratory. The plant is checked daily for high oxygen concentration around the machines and cold box, for any sign of leaks. This precaution is also taken before any maintenance is done. The filter is derimed when the pressure drop reaches 5 psig or any acetylene shows in the test. The regenerators and warm exchangers are derimed on a weekly cycle. The plant is guaranteed to operate without a general deriming for one year, but we expect it will operate for two years before deriming is necessary.

The two plants are operated by three men on each shift with two spare men on days for maintenance and charging the desiccator, deriming, etc.

Cooling water is provided by a 2000-gpm recirculating water tower using city water to make up evaporation losses and leaks. Electricity is brought to the oxygen plant at 13,200-v and reduced to 2200 and 550 v at the plant. Two separate incoming lines and transformer banks are used for reliability.

Maintenance of an oxygen plant responsible for the steel mill operation must have one goal in mind—that is continuous operation.

Maintenance is divided into two classes: work outside the cold box and work inside the cold box.

Preventive maintenance outside the cold box is similar to power house maintenance. The turbo-compressor is inspected annually for bearing wear and erosion of the turbine blades and sealing rings. The booster compressor is similar to a conventional air compressor and the valves are changed at regular intervals. On this operation, it is desirable to change two valves at a time and get the machine back on the line. This avoids loss of liquid in the cold box and the plant warming up through being idle.

The most critical unit outside the cold box is the expansion engine. Two are provided so one may be operated while the other is shut down for repairs. The expansion engine is a single cylinder, reciprocating, double acting engine, which expands the cold air from 350 psig to 65 psig. If this engine is not operating efficiently, the high pressure circuit will be unable to provide the necessary refrigeration to keep the plant going. For this reason, the valves are changed every three months and reground. The leathers on the piston are changed at the same time. It is not possible to use any lubrication in this unit, so there is considerable wear on the piston leathers. We have experimented with forged aluminum pistons and teflon packing to decrease wear on the glands and piston leathers.

Maintenance outside the cold box is routine. It is the work inside the cold box which presents the biggest problem to steady operation.

The following are two examples of maintenance inside the cold box:

Two years ago, the post filters developed a high pressure drop which could not be eliminated by deriming. Investigation showed that the sova bead was getting out of the main filter and blocking the post filter. The plant was shut down and derimed and the filters removed and new ones installed. This operation proceeded on schedule and after two days the plant was ready to start up.

The first time the plant was started, the high pressure circuit could not produce sufficient liquid air to get the plant on stream. After working for two days, a leak was discovered in the flange of the liquefier. This was repaired and the plant restarted.

However, during the start-ups, moisture got in the plant which subsequently froze and plugged the line between the cooler and low pressure column. The plant had to be derimed a second time and restarted. During this delay, a dew point indicator was first used for checking the dryness of the outgoing air. A dew point of --25 F was reached and the plant then started without further difficulty. These unforeseen difficulties stretched a 5-day shutdown to 10 days.

Recently the recorder on the regenerator pressure showed an irregularity on the low pressure side. The rock wool was removed from around the clappet boxes and a leak could be heard distinctly. It was decided to try to change these valves without deriming the plant. To do this, the plant was shut down and the pressure released, and some liquid was drained so the valves could be seen. One high pressure valve had completely disintegrated and the second was badly worn. These valves were changed and the plant put back into operation in three hours. This repair was carried out at −280 F, in the clappet box which made working conditions very difficult.

Figure 3 — Maintenance work must be done often in very cramped quarters.

Figure 3 shows the location of the job, and the cramped quarters. Performing this job without deriming changed a 96-hour delay to three hours.

An oxygen plant is different from most steel mill equipment, in that it is impossible to see exactly what is going on inside the cold box. The only indication of trouble is changing pressures or temperatures.

In addition to this, there is the delay in getting the plant back on stream after starting-up. These factors place a heavy responsibility on the plant operators.

The best maintenace is a good operator who is alert and can translate changing pressure or temperatures into what is happening inside the cold box and take the necessary preventive steps to eliminate the trouble.

In conclusion, Dominion Foundries & Steel Ltd., have been pleased with the performance of the oxygen plant and melt shop. In 1956, a second 100-ton unit was installed with a third oxygen furnace to increase the steel production to 2000 tons per day.

"MAINTENANCE EXPERIENCE WITH O_2 PLANTS AT SPARROWS POINT

by A. STUTZER, General Foreman
Prepared Gases Station, Fuel Dept.
Bethlehem Steel Co.
Sparrows Point, Md.

THERE are six oxygen units installed at Sparrows Point, four of which have been in service since late 1952 and two of which went into service at the end of March and beginning of April of 1957. These units are all essentially identical in design and are rated at 7000 cfhr of high purity oxygen. Although primarily designed to produce high purity oxygen, we at Sparrows Point also utilize the by-product high purity nitrogen produced by these units. This nitrogen is used in a prepared atmosphere for box annealing, and must be available more or less continuously since there is only enough storage available for emergency purposes. Therefore, the necessary maintenance on the oxygen units must be of a planned nature and breakdowns must be kept to a minimum. It is for this reason that we have spent considerable effort in establishing an effective and workable maintenance program.

The major components to be considered in the program are: (1) the air compressor; (2) the air purifier; (3) the air drier; and (4) the air separator. The air separator can be further broken down into: the liquid oxygen pump; the distillation column and the heat exchangers. As would be expected, many questions had to be answered before any program could be established. For example: How long could a unit be in service before it becomes impossible to control the unit because of excessive frost? How long will a set of air compressor valves last before they begin to fail? How long will the liquid oxygen pump packing last? To get the answers to these and other questions we used the manufacturer's experience and our own experience on four smaller units of similar design, and applied this knowledge to our 7000-cfhr units. As may be expected, this knowledge had to be modified by actual experience on the 7000-cfhr units.

After some months of operation it became evident that the maintenance program would be governed by the length of time a unit could run before it had to be defrosted. This turned out to be an average of approximately 1100 operating hours. We then adjusted the maintenance of the various components to this period of time.

Let us take each major component, as mentioned previously, and see how each was adapted to the magic number, 1100 hr. The first unit mentioned was the air compressor. Our compressors are 4-stage, horizontal, duplex design with double acting first and second stage cylinders mounted on one frame and single acting, opposed third and fourth stage mounted on another frame. The major maintenance items on the air compressors are the compressor valves, belt drives on the four older units, cylinder lubrication system, crankcase lubrication, and inspection of crank disk and bearings. Taking each of these items individually we will see how their particular characteristics fit into the master plan.

First, the air compressor valves. We found that our compressor valves started giving us trouble when they had been in operation about 2500 hr. Therefore, we decided to change all valves every 2200 hr, or every second defrost. This has worked out very satisfactorily and now we only have a very occasional failure with less than 2200 hr of operation.

Second, the belt drives on the four older units. This is a multiple V-belt drive which transmits approximately 250 hp. These belts are inspected every 1100 hr and adjusted at that time. Up to this time we have had to replace only one set of the four sets in operation.

Third, the cylinder lubrication system. This is a force feed system and the complete system including the individual cylinder check valves are inspected every 1100 hr. The system is cleaned and flushed every 6600 hr. We feel that the close inspection of this system has prevented any possible compressor fires, air side fouling of the intercoolers and aftercoolers, and fouling of our drier desiccant bed.

Fourth, the crankcase lubrication. The crankcase is lubricated by a flood system. Since the inception of our maintenance program, we have progressively increased the length of time between oil changes so that now we drain, clean and flush the crankcase every 6600 hr.

Fifth, the inspection of crank disk and bearings. Approximately two and a half years ago we experienced a failure of the weld that holds the crankpin in the crank disk. This allowed the crankpin to work out of the crank disk and to drop into another hole in the crank disk. This jammed the machine and stalled the motor. An inspection showed that the connecting rod had a sharp bend, the crankpin bearing was ruined, the babbitt on the crosshead had been slightly wiped, and the third stage piston and cylinder were scored. Ever since this failure, we inspect the weld between the crankpin and crank disk every 2200 hr, with the hope that any future failure of this weld can be detected before any serious damage occurs.

In addition to these items all electrical equipment, including motors and related switch gear, are cleaned and serviced 1100 hr.

The second major component of our oxygen unit is the air purifier. This consists of two towers in which caustic solution is circulated to remove the carbon dioxide from the compressed air. Our maintenance items on the purifiers are the caustic circulating pumps and the strainers in the pump suction lines.

There are two pumps per unit: one a single stage, the other a two-stage turbine type pump. These pumps are repacked every 1100 hr and completely rebuilt once every year. We have found that we experience minimum shaft leakage and damage by repacking these pumps on this schedule. The suction line strainers are dismantled and cleaned on this same schedule (i.e., every 1100 hr).

Our third major component, as mentioned earlier, is the air drier, which is a dual tower type of unit filled with standard activated alumina and provided with a rotary blower to force nitrogen through the towers for reactivation. On this component, the items considered in the maintenace program are the blower, the desiccant bed, and the air and nitrogen valves. Maintenance on the blower consists of cleaning, flushing and changing oil in the gear case every 6600 hr and inspecting the V-belt drive every 1100 hr. We have not had to make any other repairs to these units since they have been in operation.

The air and nitrogen valves seats and disks are inspected every 2200 hr and the stems and threads are lubricated at the same time. We have had to replace six seats and disks out of a possible 24 since the units have been placed in operation.

In order to keep a check on the condition of the desiccant bed, a sample of desiccant is taken once each year. The sample is checked for oil contamination and anything else that may indicate fouling of the desiccant bed. All of our units still have the original charge of desiccant.

Now for the fourth and final component of our oxygen unit—the air separator. The two parts of this unit that have to be considered in the maintenance program are the expansion engine and the liquid oxygen pump.

The expansion engine is a single cylinder, single acting, vertical type engine with spring-loaded ball-type inlet and exhaust valves. Maintenance on this engine is accomplished in two steps. First, every 1100 hr the piston cup leather is inspected and replaced if necessary, and the inlet and outlet valve clearances are adjusted. Second, every 2200 hr the inlet and outlet valve rods are replaced, the piston body is replaced, the piston rod inspected and replaced if necessary, the piston rod and valve rods repacked, the cylinder walls inspected and honed if necessary, and all bearings inspected. In the almost five years of operation of these plants, we have replaced the main connecting rod bearings and the cam follower bearings on two of our expansion engines.

Our final unit in our maintenance program is the liquid oxygen pump. The pumps on our units are reciprocating plunger type pumps designed for delivery pressures up to 2800 psig. The maintenance involved on these pumps is the defrosting and repacking of the pump every 1100 hr. Repacking the pump consists of replacing the plunger, bushing assembly, packing gland assembly, and, of course, the packing materials, which consist of hard graphite rings, asbestos rings and flake graphite.

All of the items mentioned herein make up the maintenance of the oxygen units at Sparrows Point. With this program our units are down approximately 3 per cent of the possible total operating time because of

maintenance. This may appear to be a great deal of downtime for maintenance, but because of this program we are able to maintain a continuous flow of nitrogen for the prepared atmosphere consumed by our box annealing furnaces, which though a by-product of our oxygen units, quite frequently takes such precedence over our oxygen production that at times the term "oxygen unit" may be a misnomer.

"OXYGEN PLANT CYCLES TAILORED TO REQUIREMENTS OF IRON AND STEEL PRODUCERS"

by CLARENCE J. SCHILLING

Vice President and Chief Engineer

Air Products, Inc.

Allentown, Pa.

TO be of use in the steel industry, oxygen must meet numerous requirements:

1. Purity—This may be 95 per cent for such applications as blast furnace enrichment. More frequently 99.5 per cent is required for general use in the steel industry.

2. Oxygen must be available at different pressure levels: from a few psi in some applications to 150 psi for pipeline uses, and up to 2500 psi for filling oxygen cylinders.

3. Oxygen demand may be either constant or variable. If variable, gaseous oxygen storage capacity may be needed to handle peak requirements.

4. Oxygen must be available on demand, the equipment generating this oxygen should be reliable.

5. Oxygen must, of course, be produced economically.

With the above needs in mind, let us review several cycles which meet these requirements.

While various methods of producing oxygen have been tried, including electrolysis of water, semipermea-

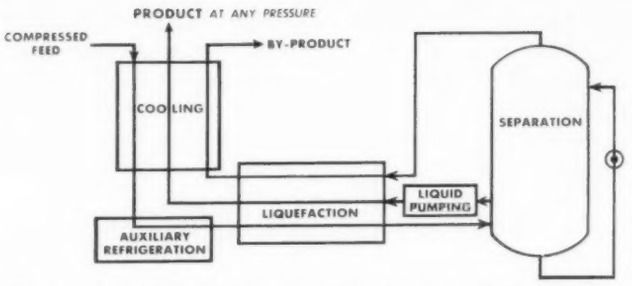
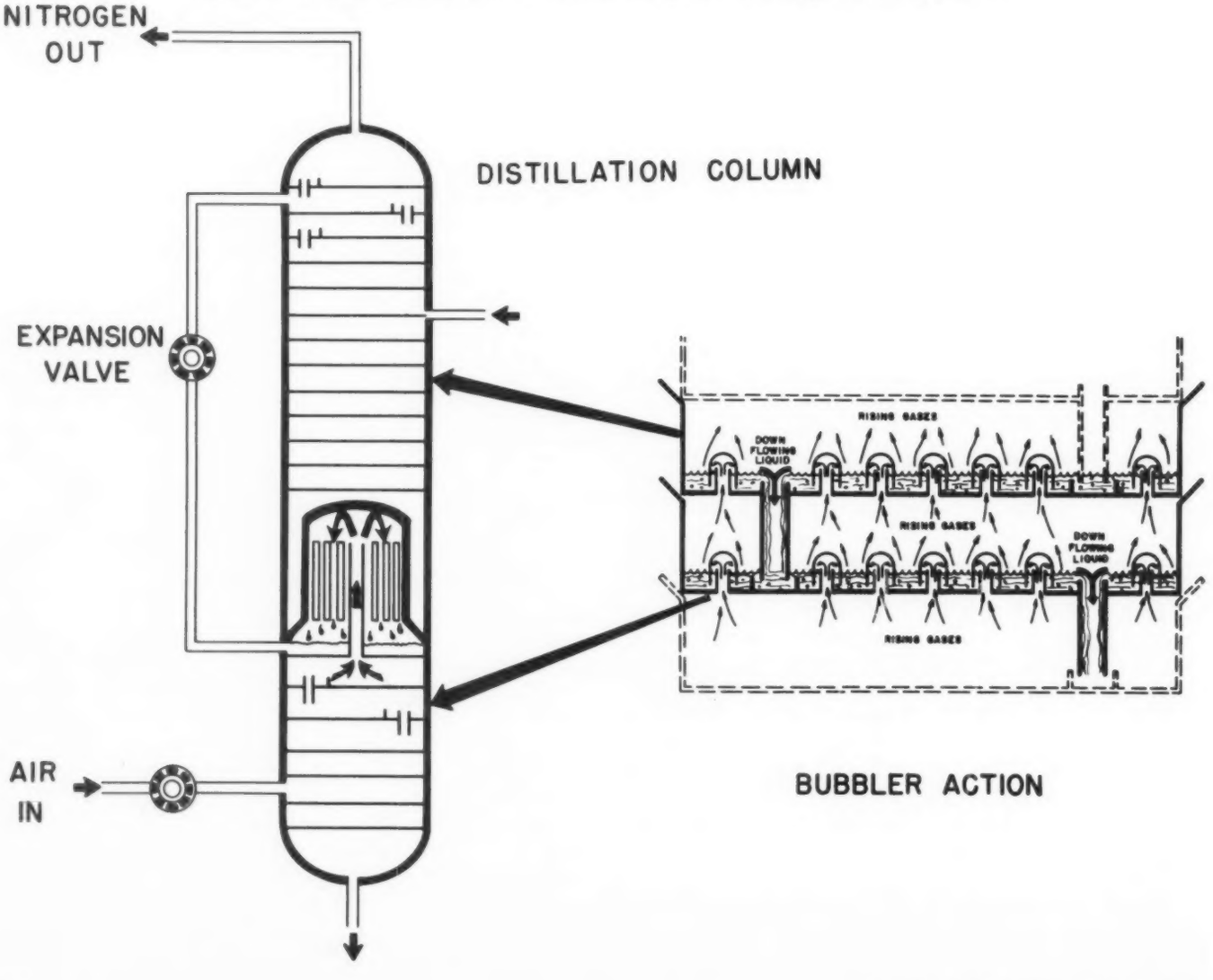


Figure 1 — Generation of oxygen is a four-step process.

Figure 2 — A distillation column is an essential part of the oxygen-making process.



ble membranes, and so forth, only one method—the fractionation of air—has really resulted in the economic production of oxygen in tonnage quantities. Let us consider the method of fractionation.

Figure 1 is simply a schematic of the four-step process requirements for the generation of oxygen. Compressed air is water-cooled, refrigerated in a heat exchange system, liquefied, and, finally, the air is distilled. The components producing these effects include air compressors, heat exchangers, regenerators, refrigeration systems, expanders, and distillation apparatus.

Common to all oxygen cycles is a distillation column as shown in Figure 2.

A typical air distillation column is a two-pressure system in which air enters the first, or high pressure column at about 85-psi pressure. In this "high pressure column," the air is separated into two portions: (1) gaseous nitrogen, and (2) liquid bottoms containing substantially all of the oxygen.

Rising nitrogen vapors in the high pressure column are then liquefied in the condenser-reboiler section (center) and are divided into two streams: one, which is expanded to form the reflux liquid for the low pressure column; and another, which provides reflux and washes the trays in the high pressure column.

The liquid bottoms from the high pressure column, containing all the oxygen, are then expanded through a valve to a reduced pressure and fed into the low pressure column at a medial point, resulting in additional reflux liquid below the feed point.

The purpose of the column, of course, is to create a very intimate action between the rising vapors, as illustrated here, and the down-flowing liquid, flowing across each tray and running down the down-pipe to the tray below.

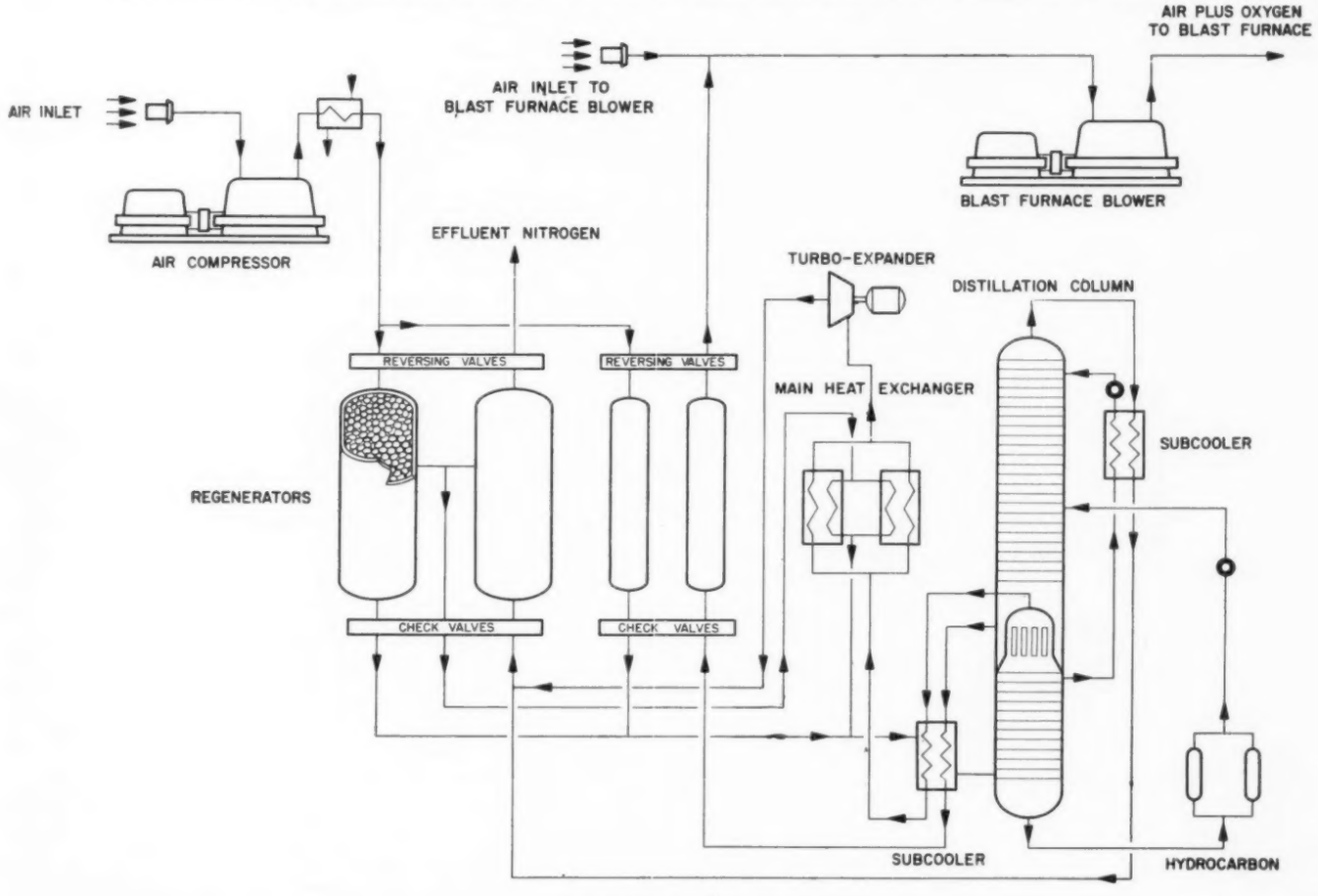
To provide intimate vapor-liquid contact, either bubble cap trays or equivalent sieve-type trays are used in the columns, their number dictated by the purity of the oxygen required, and the percentage recovery from the air that is desired.

It is interesting that, irrespective of which type of refrigeration cycle may be used, the distillation column is, by comparison, a fixed entity. The action of the gases and the liquids is such that stepwise the nitrogen purity increases from tray to tray until there is substantially pure nitrogen at the upper level. The liquid is increased in purity from tray to tray until pure oxygen surrounds the reboiler at the intermediate level.

If gaseous oxygen is to be withdrawn from the column, the low pressure column is tapped at a level immediately above the liquid; but if liquid oxygen is required, it is drawn directly from the liquid bath.

All of the various cycles under consideration here are somewhat different, from the fact that you have the choice of withdrawing gas, liquid, or a combination of the two from the column, and this difference is recog-

Figure 3 — This low pressure cycle is ideally suited for production of oxygen in steady state conditions.



LOW-PRESSURE CYCLE
(100 PSIA)
OXYGEN AT 2 PSIG, 95-98% PURITY

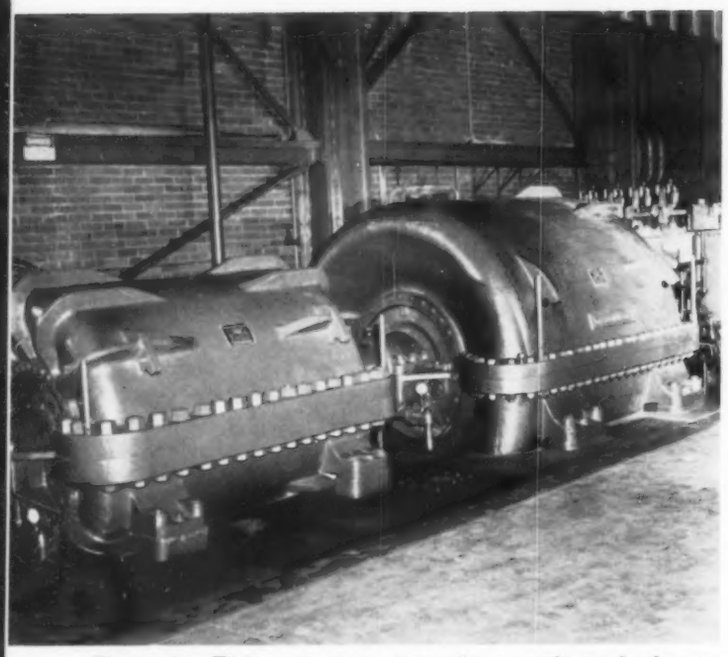


Figure 4 — This compressor is used on a unit producing up to over 500 tons per day.

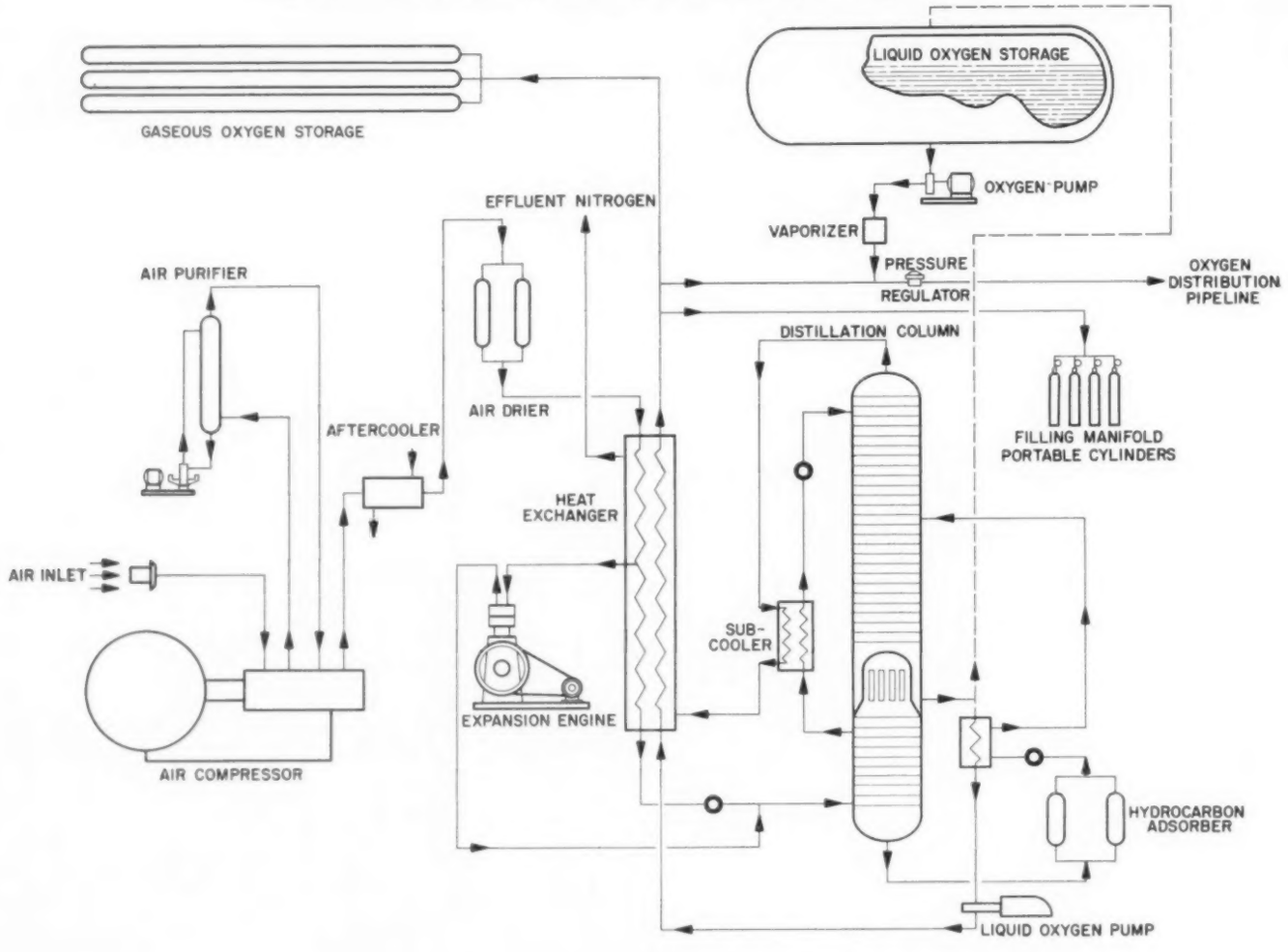
nized entirely by the condition of the air coming into the column. For example, if you have a straight low-pressure plant, this air is essentially saturated vapor. If you have a full liquid plant, the air feed to the high pressure column has liquid present in it with a refrigeration value equal to the liquid withdrawn with the oxygen product, and so on for any intermediate condition of part gas and part liquid.

Figure 3 illustrates the low-pressure cycle which is ideally suited for production of oxygen gas in steady state conditions and in large capacity. The essential features are:

The compressor and after-cooler provide the plant with pressurized air at ambient temperature. Heat exchange is accomplished in two regenerators, while the effluent products from the column—nitrogen and oxygen—come out through alternate sets of regenerators. The regenerators, in addition, perform the function of freezing out and eliminating impurities in the air; namely, water at a near-ambient temperature level and carbon dioxide at a lower level.

In the process of warming up, each outgoing product cools the packing in one regenerator while the feed air is being cooled in the alternate regenerator and the im-

Figure 5 — This medium pressure cycle uses a reciprocating compressor.



MEDIUM PRESSURE CYCLE
(400-1000 PSIA AIR)
OXYGEN UNDER PRESSURE, PLUS LIQUID OXYGEN SIDE STREAM, ALL AT 99.5% PURITY

purities deposited on the packings. Periodically, the reversing valves switch the direction of flow in all regenerators, the effluent streams go out the alternate regenerators, and the air comes in through the cold regenerator that had been warming up the outgoing products before the switch.

By these means the impurities are now included in the effluent products, and the system is able to go on indefinitely.

The low pressure plant requires the minimum refrigeration of any to be discussed, since it is not removing any liquid from the system. Additional refrigeration, as needed, is supplied by expanding dry nitrogen gas from the high pressure column in a turbo-expander. Prior to expansion, the nitrogen is partially heated in an exchanger against an air stream split from the regenerators. This protects the expander against formation of erosive liquid in the turbine, adds thermal efficiency, and aids in cleanup of the CO_2 from the air.

This expanded nitrogen is then added to the nitrogen leaving the column, and together they cool the regenerators, maintaining cold in the plant.

OXYGEN APPLICATION

The oxygen in this case, in a typical example, would be added to the wind, to speed up a blast furnace, and, as Mr. Strassburger mentioned, the normal addition here provides for an enrichment of from one to four per cent, depending on the desires of the user.

It is interesting to say that in plants using this cycle, which are usually quite large, the major refrigeration need comes about from the temperature difference necessary to effectively operate these regenerators. This is the major load. The minor load is that of heat infiltration, since the entire system in the cold box operates from ambient temperature to about 314 F below zero.

Figure 4 shows a compressor, in this case the compressor for the tonnage plant at Weirton, which has produced at a maximum rate of 525 tons per day.

Figure 5 shows the medium-pressure cycle. The compressor in this case is a reciprocating machine, since the pressures employed vary from 400 psi upward, depending on the quality and pressure of the oxygen that is produced. The purification of CO_2 is performed interstage.

In this cycle, air is dried in a desiccant type drier where moisture is removed on one side, while the other side is being regenerated, and they are periodically switched. The air, then under pressure, enters the heat exchanger, and for the most part is then expanded through an expansion valve to the high pressure column.

A fraction of the air is brought from the heat exchanger through a reciprocating type expansion engine, and it is finally reintroduced into the high pressure column, which operates at about 85 psi, this being the case for all cycles so far as the high pressure column is concerned.

The major portion of the refrigeration needed here is supplied by the Joule-Thomson effect across the air expansion valve. However, the expansion engine is employed to save power by making the necessary refrigeration at a lower air pressure.

It is important to note that any maintenance of the expander will not put the cycle out of commission. We can keep the oxygen production intact by simply raising the air pressure to a level which was anticipated in the original design.

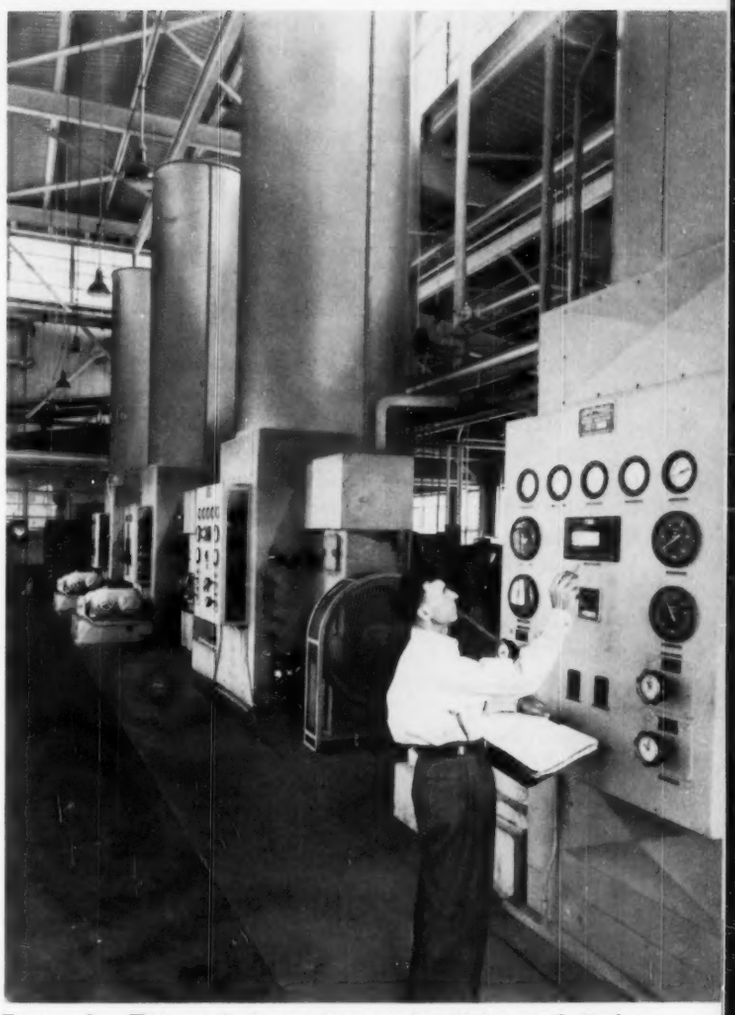


Figure 6 — This unit has extreme simplicity and flexibility.

The cooling of the air in this case is performed by tubular heat exchangers instead of regenerators, and due to the pressures involved these are ordinarily coiled tube type, the pressurized air and oxygen being inside the respective tubes.

Oxygen is removed from the column as a liquid, and passes into a self-lubricated pump, where the pressure is raised anywhere from 150 to 3000 psi, and the liquid oxygen, under pressure, is evaporated countercurrent with the air and fed into storage, or into cylinders. A stream of liquid may also be withdrawn, if desired, and fed directly into liquid storage, if the requirements are such that liquid storage is indicated.

Figure 6 exemplifies the medium pressure cycle and is illustrated here in four plants installed at the steel works of the Ford Motor Co. The advantage of this cycle is the extreme simplicity and flexibility which it has. It can be operated simply; it can be started promptly; it needs a minimum of attention, and it is usually applied to requirements of a critical nature.

The units are ordinarily supplied in multiple, in addition to storage, which gives extreme flexibility to this type of requirement.

Figure 7 pertains to the high pressure cycle, which has for its object the production of the total output of oxygen as liquid. Liquid is put into storage, and then trans-

ported to a steel mill or other point of use. The cycle has very great similiarity to the medium pressure cycle in that you also have a reciprocating compressor, the pressures here being of a nature of 2500 psi, however.

The clean-up system is the same; the drying is the same; the heat exchanger is similar, except the pressures are higher. The expansion engine employed is again a reciprocating type which must be designed for 2500 psi pressure, and the combination of air from the heat exchanger and the expander air are introduced into the column. The refrigeration requirements of this cycle, of course, are much larger, since the total production is a liquid and you do not get the benefit of the oxygen cooling the incoming air as in the other cycles.

The expansion engine in this case performs a much more important function. About fifty per cent of the total refrigeration is produced by this engine. Therefore, it must be well designed and well maintained.

Figure 8 shows an example of plants employing the high pressure cycle. There are numerous plants illustrated here of about 75-ton capacity each, producing liquid oxygen and also, in this case, liquid nitrogen for missile use. The requirement here is, of course, large quantities of liquid oxygen.

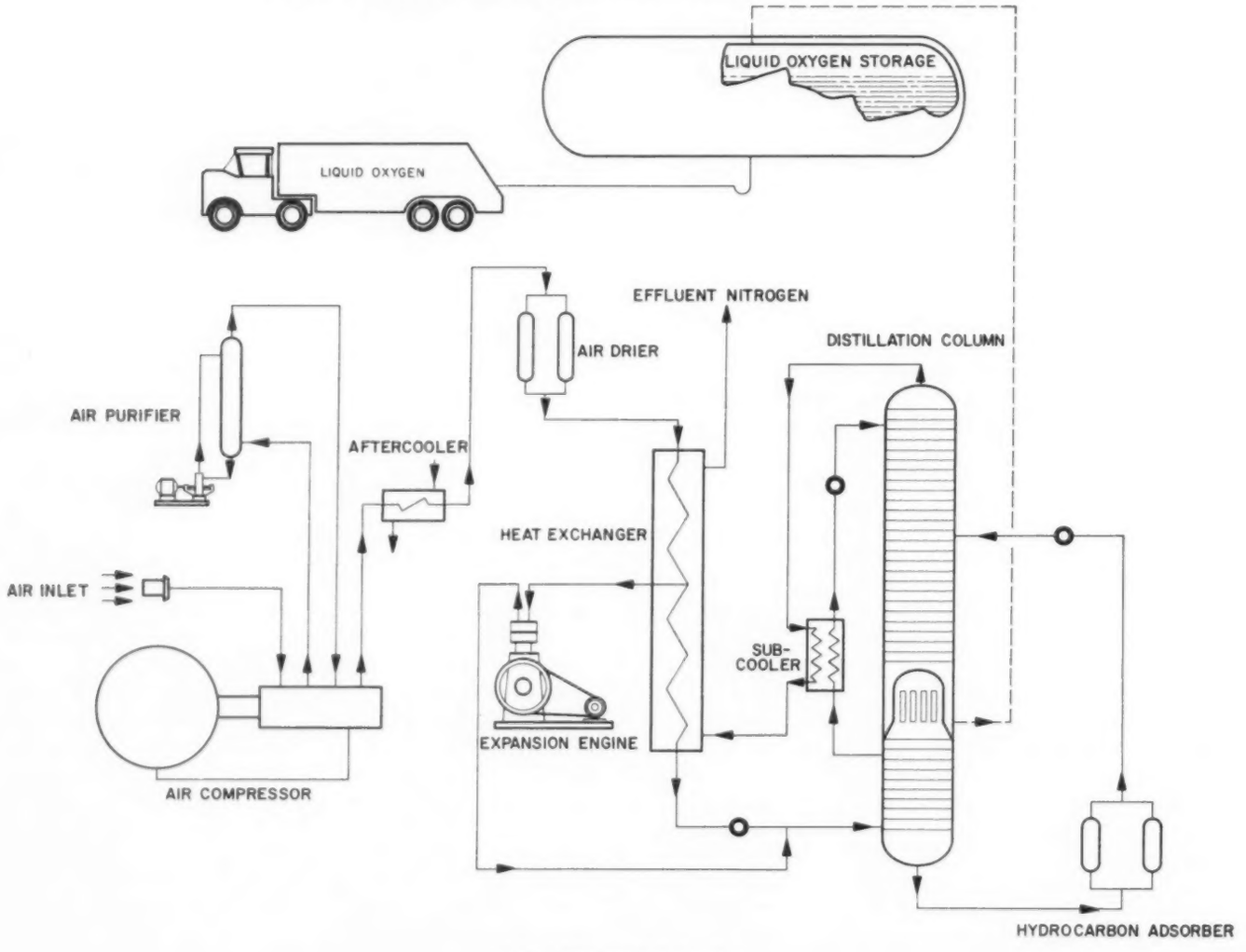
Figure 9 outlines our new mixed pressure cycle, a combination of high and low pressure cycles. There is similarity to the low pressure cycle brought about by the fact that all of the air is first compressed to a pressure of about 85 psi. The difference begins as a portion of the air is chemically cleaned up, compressed to a high pressure in a booster compressor, water-cooled, dried, and separately refrigerated in a heat exchanger; whereas the major portion of air is cooled and regenerated as previously described.

The interesting example in Figure 9 shows a four-fluid heat exchanger in which liquid oxygen is vaporized and warmed up at two different pressures. Low pressure gaseous nitrogen is also warmed. The three cold products give up their refrigeration to cool incoming air. The oxygen from the reciprocating pump is delivered at 2500 psi, while that from the larger, centrifugal pump is delivered at about 450 psi pressure.

The other stream of oxygen in this plant is a quantity of liquid which is continuously put into liquid storage. This liquid storage provides a large emergency reserve for maintenance of the generator, whereas the gaseous storage takes care of the normal variation in use pattern.

The mixed-pressure cycle, in Figure 9, is very versa-

Figure 7 — High pressure cycle is used for production of liquid oxygen.



HIGH-PRESSURE CYCLE
(2000-3000 PSIA AIR)
LIQUID OXYGEN AT ATMOSPHERIC PRESSURE 99.5 % OXYGEN PURITY

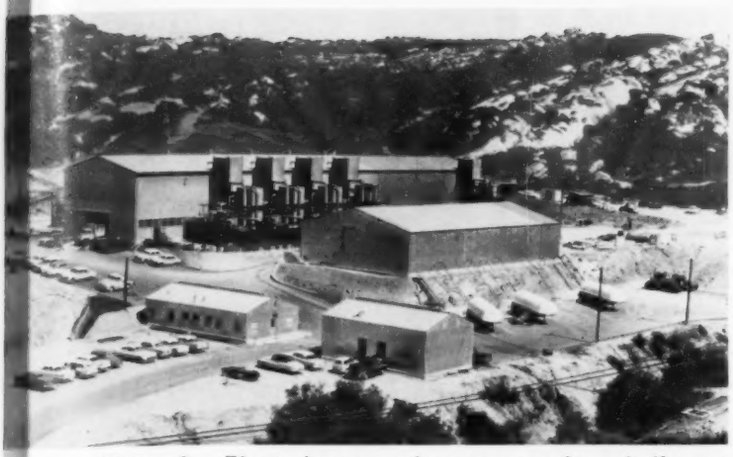


Figure 8 — Plant shown produces oxygen for missile use.

tile, in that by proportioning the percentage of boosted air or by changing the booster pressure, it is possible to make almost any percentage of the plant capacity as a liquid. The cooler shown here refrigerates a part of the air which is taken out of the exchanger, and subsequently reintroduced. This is a simple means for providing extra refrigeration to the cycle. Applied in this way, a small unit adds safety factors in productive capacity far out of proportion to its share of the total power load.

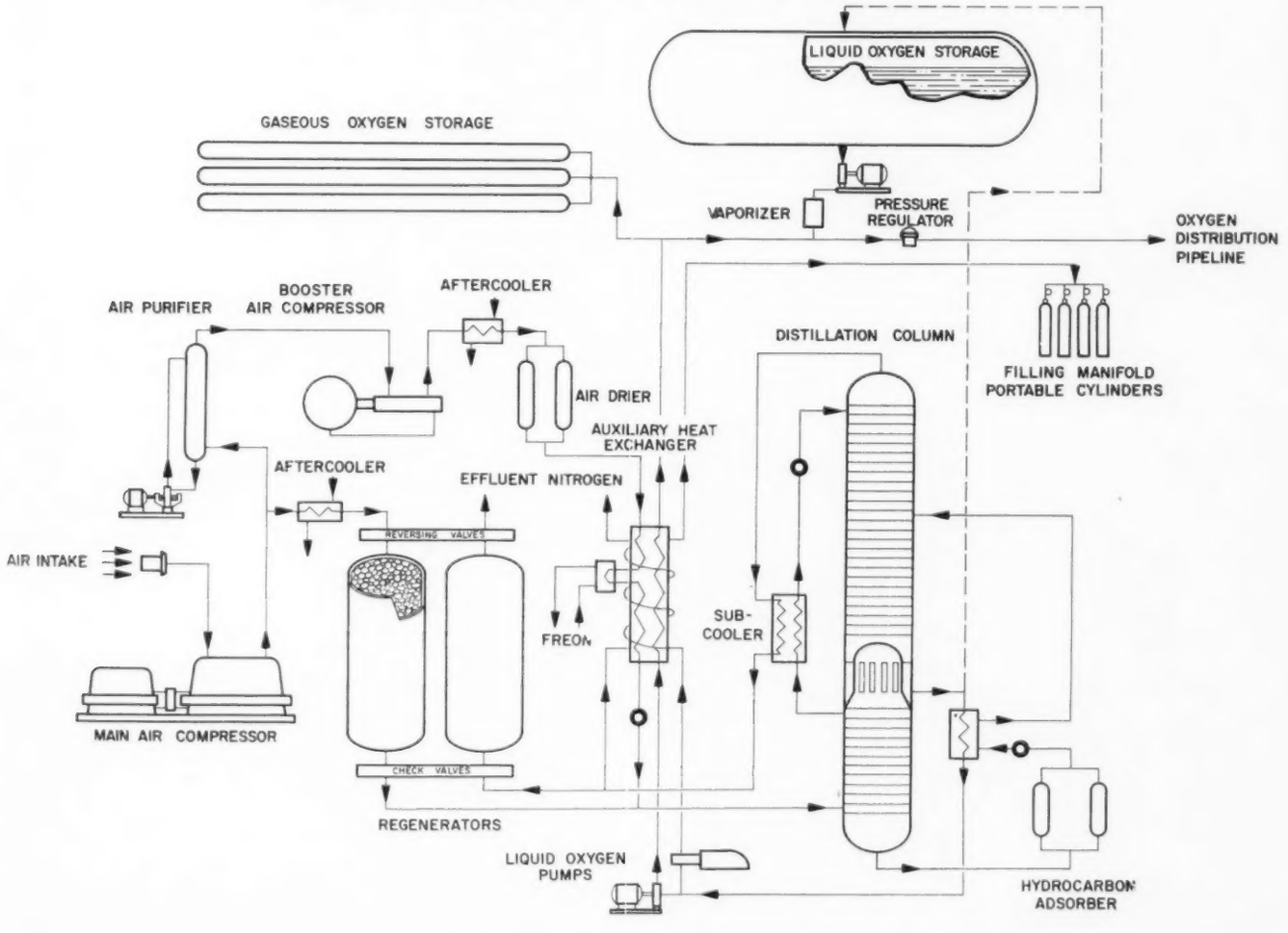
This cycle further has the advantages that, where purities are important—and these are generally all 99.5 per cent purity cycles, except the low pressure—we have two entirely pure oxygen streams. In addition, a nitrogen stream which comes into the shell side of the heat exchanger is also at high purity, uncontaminated by water or CO_2, and is available for special uses.

Figure 10 shows two plants at Aliquippa, Pa., which constitute a 230-ton per day system for supplying high purity oxygen and nitrogen. The installation includes two generators, a gaseous storage bank, and a considerable amount of liquid storage. These plants are of the cycle shown on Figure 9. The two units, together, provide 230 tons of oxygen per day.

Other typical uses for this cycle, in addition to oxygen converters, might include open hearth uses or other critical oxygen uses in any quantity whatsoever.

Table I relates all these cycles on a power-cost basis. We have assumed here a plant of approximately 100-ton capacity, and we have assumed oxygen compressor efficiency of 65 per cent; the air compressors, reciprocating type, at 75 per cent; with the centrifugal type at 65 per cent. The low pressure cycle, of course, has just two power inputs. The oxygen compressor consumed 6.62 hp per ton per day; the air compressor, 19.65; the expander contributes a small saving to the cycle, giving a total indicated power of 25.88 hp per ton per day.

Figure 9 — This unit combines high and low pressure cycles.



MIXED-PRESSURE CYCLE

OXYGEN UNDER PRESSURE, PLUS LIQUID OXYGEN SIDE STREAM, ALL AT 99.5% PURITY

Figure 10 — J & L installed two 115-ton-a-day plants to supply oxygen to top blown oxygen converters.

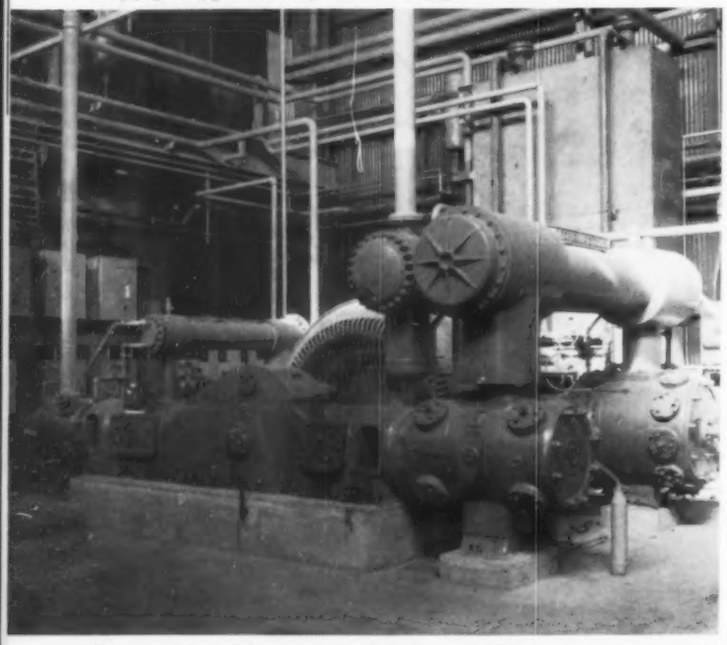


Figure 11 — Air compressor for medium pressure cycle producing about 25 tons a day.

Figure 12 — In heat exchanger, oxygen goes into header and passes through a number of tubes in parallel.

For a medium pressure cycle on the same basis, in this case, 450 psi oxygen also—we have assumed 550 psi will be the air feed pressure. The air compressor requires 32 hp per ton per day. The oxygen pump needs 0.16; the expander in this case supplies a little more power, and the net is 31.52 hp per ton per day of capacity.

A high pressure cycle has a 2500-psi air compressor. It uses 51.5 hp per ton per day. The expander in this case returns 3.6 hp; the net is 47.9 hp. It must be remembered, however, in this case liquid oxygen is being produced.

The mixed pressure cycle would have a primary compressor which could be identical with the low pressure cycle of 19.65 hp per ton per day. The booster compressor uses about 7.15 hp per ton per day.

The refrigeration compressor, if employed, would have 0.25 hp per ton per day, giving a total of 27.2 hp per ton per day.

The ratio of power values is shown at bottom with the basic low pressure cycle having a power index of one, comparative power consumption is about 22 per cent higher for the medium pressure cycle, the high pressure cycle is 85 per cent higher, and the mixed pressure cycle five per cent higher.

This five per cent is certainly a very small penalty for the flexibility which has been mentioned in terms of liquid, some high pressure oxygen and some at medium pressure.

Perhaps it will be helpful to look at some of the components used in these cycles. An air compressor is shown in Figure 11. This is, in fact, the type employed in a medium pressure cycle of the 20 to 25 ton a day variety. It would be a similar compressor, as a booster machine in a plant three or four times as large of the mixed pressure cycle. More cylinders would be needed for the air source for the high pressure cycle—with, of course, more horsepower installed.

Figure 4 shows the centrifugal type of compressor,

TABLE I

Power Comparison for Various Oxygen Cycles to Produce 100 Tons per Day of 99.5 Per cent Oxygen at 450 Psig

Equipment	Low pressure cycle, hp per ton per day oxygen	Medium pressure cycle, hp per ton per day oxygen	High pressure cycle, hp per ton per day oxygen	Mixed pressure cycle, hp per ton per day oxygen
85-psi air compressor	19.65	...	...	19.65
450-psi O_2 compressor	6.62	...	...	...
550-psi air compressor	...	32.00	...	...
450-psi O_2 pump	...	0.16	...	0.16
1500-psi booster air compressor (30 per cent only)	...	...	...	7.15
2500-psi air compressor (100 per cent of air feed)	...	...	51.5	...
Refrigeration compressor	...	...	...	0.25
Expanders	−0.39	−0.64	−3.6	...
Total hp per ton per day	25.88	31.52	*47.9	27.21
Horsepower ratio	1.00	1.22	1.85	1.05

An air intake of 9000 scfm is assumed in each case.
* Oxygen product is removed as a liquid from the air separation equipment.

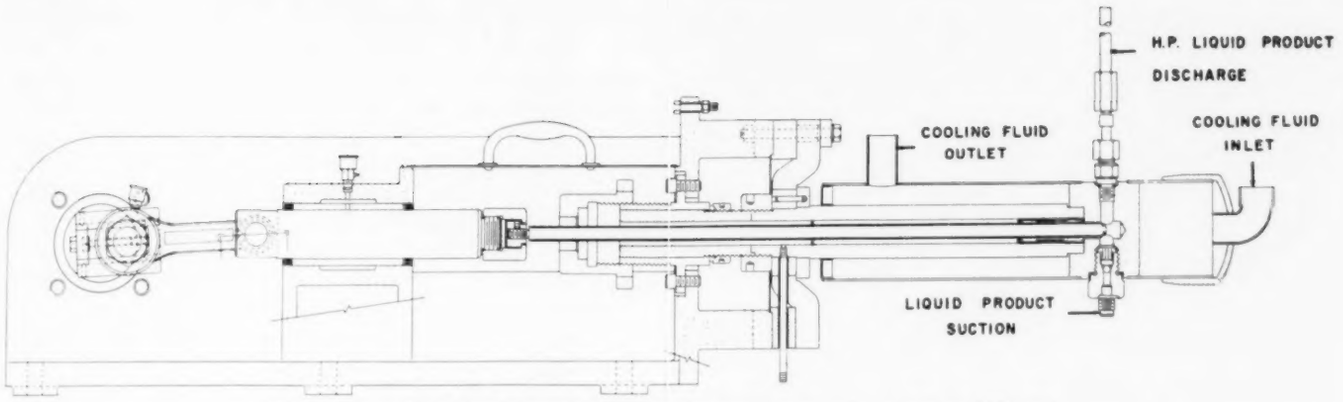


Figure 13 — This liquid product pump is used for pressures up to 3000 psi.

which is useful either as the primary air compressor for 85 psi, in the low pressure cycle, or for that part of the air for the mixed pressure cycle required at this pressure.

Figure 12 shows a heat exchanger as used in the various cycles where air is under pressure, comes into a header, and then passes through a number of tubes in parallel. It comes out the opposite end as partially liquid air, ordinarily. The oxygen, under pressure, enters a similar header and passes through another group of tubes.

The nitrogen is in the shell side, and it actually enters the shell countercurrent to the air and comes out at the ambient temperature.

Figure 13 is a schematic of a liquid product pump for the production of oxygen under pressure. This sort of pump is used for any pressure up to 3000 psi. It will be noted that a cooling jacket surrounds the cylinder; and, because of the high density of the liquid—namely, about 850 times that of gaseous oxygen—the plunger, of course, is quite small. It is purely a hydraulic pump, and the outlet pressure from the plant is maintained constant as the oxygen evaporates in the heat exchanger.

Figure 14 is the counterpart of Figure 13 in a centrifugal pump, which, of course, is suited to high volumes and to pressures of up to 600 psi or thereabouts. It is operating very successfully as a liquid oxygen pump.

Figure 15 shows a comparison of a reciprocating expander which is used when the air pressure is very high, and the expansion ratio is also high, like expanding from 2500 psi to 100, or 1500 to 100. It is simply a crankcase down below, with the cold end in the upper regions and valves timed to open for inlet and exhaust.

The small expander shown at the left in Figure 15 is a centrifugal counterpart, and in this case these two machines are used for identical air flows, but for different pressure ratios—the reciprocating machine for the high pressure ratio, and the turbine for about a 5 to 1 pressure ratio with the same throughput.

Figure 16 shows a cutaway of the centrifugal expander, which is a very nice little unit. The air comes in radially, through a nozzle ring, and through a radial inflow turbine, and is finally exhausted parallel to the axis of rotation. In this case, the attached blower moves

Figure 14 — Liquid product pump here shown is of the centrifugal type.

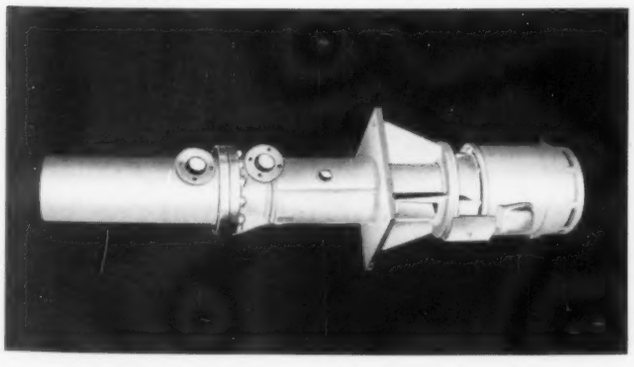
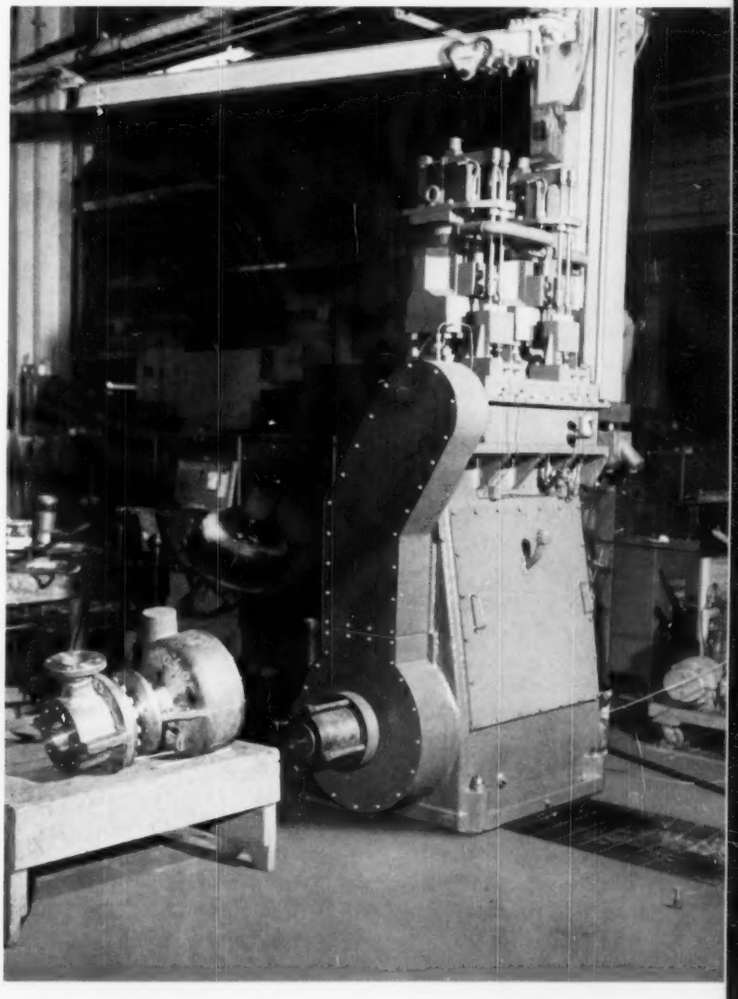


Figure 15 — Centrifugal expander is much more compact than the reciprocating type.



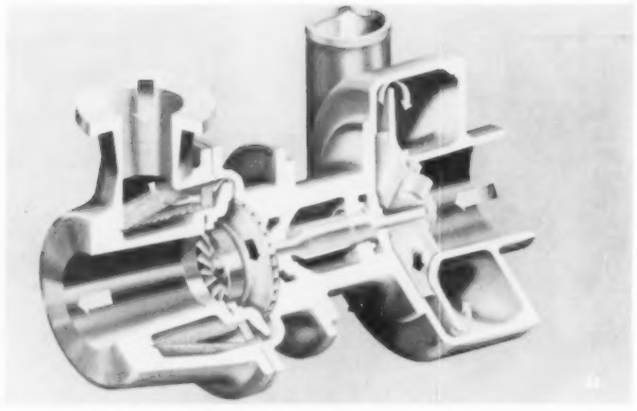


Figure 16 — Cutaway view of centrifugal expander.

air, or any other gas to be compressed, exhausting in conventional manner. The blower is an excellent loader, permitting close control of the expander speed and load.

We feel that the cycles shown, properly applied in steelmaking, have made available economical oxygen for every need. Recognition of the advantages of low cost oxygen generated on-site by steelmakers has sharply increased consumption of oxygen per ton of steel produced. We are quite sure all steelmen will continue to be resourceful in finding increasing use for oxygen in ways both new and old.

For ourselves, we hope to be equally resourceful in meeting this demand by continuing to develop the means whereby oxygen may be produced most economically.

Discussion

PRESENTED BY

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MARTIN J. CONWAY, Consulting Engineer, Steel Mill Utilities, Millersville, Pa.

CLARENCE J. SCHILLING, Vice President and Chief Engineer, Air Products, Inc., Allentown, Pa.

J. H. STRASSBURGER, Assistant Vice President, National Steel Corp., Pittsburgh, Pa.

T. J. MILHAUPT, Manager, Bulk Gas Sales, Linde Co., Div. of Union Carbide Corp., New York, N. Y.

R. A. LAMBERT, Superintendent, Steam Efficiency and Combustion Dept., Pittsburgh Works Div., Jones & Laughlin Steel Corp., Pittsburgh, Pa.

R. L. Deily: It seems to me to be significant that today's session on oxygen is the tenth anniversary, almost to the day, of the first session on oxygen. In 1947, here in Pittsburgh, our Association of Iron and Steel Engineers included four papers on oxygen usage in the steel industry, in sessions on the general topic of combustion. Today, in 1957, oxygen merits top billing, and there is hardly time enough for even a broad survey of the subject.

It is worthwhile to take a look at the background of the 1947 session, along with the intervening ten years to see where we are, and where we might be going. As our chairman, Mr. Strassburger, told you, it was in the summer of 1946 that oxygen was first used metallurgically on a practical scale, when someone had nerve enough to blow large quantities of oxygen into a steel bath through a lance pipe. Only one year later, the technical journals were filled with comments on this wonderful tool that was going to revolutionize the steel industry.

However, the people who addressed the 1947 AISE session were more familiar with the tough problems of making steel, so that the situation was very wisely summed up at that session by the statement: "The future policy of the XYZ Steel Corporation concerning the use of oxygen has as yet not been determined." It was realized by the steel people that, while the use of oxygen had a tremendous amount of promise, there were many practical operating problems that had to be determined before oxygen usage was put on a firm basis.

In looking back, we can see that this experimental and development work has been going on actively in these past ten years. This work has been a co-operative effort between the oxygen-producing and steel companies, along with important contributions from our European colleagues. So, today, the metallurgical use of oxygen is firmly established for decarb, combustion, oxygen steel and enrichment.

It is no longer necessary to wonder whether oxygen will be used. The prime problem now is the economics of oxygen usage, so that today's "tenth anniversary" papers have discussed mainly how oxygen is produced and what cost factors are involved. This is a worthwhile discussion, to which can be added just a few words as to the future direction of oxygen usage by the steel industry.

Along with the other oxygen enthusiasts on the panel. I think there will be a growth of oxygen usage beyond anything now contemplated. There are three major reasons for expecting this growth: (1) the fact mentioned before that the steel industry now has great technological ability to use oxygen in basic metal production; (2) the oxygen producing capacity of the country has been growing at a fast pace to supply the high demand; and (3) the tremendous daily use of oxygen, in air, by the steel industry.

A few statistics regarding the oxygen and steel industry will illustrate how enormous the consumption of oxygen (in air) by the industry is: it can be shown that it takes approximately two tons of oxygen to make a ton of steel. This means that the steel industry in 1957 will use more than 200,000,000 tons of oxygen. How much of this is supplied as a commodity by the oxygen industry?

Well, even with all the very fine plants that have been put in and are contemplated, oxygen as a commodity is produced on the order of 2,000,000 tons per year, or only about 1 per cent of actual oxygen usage. Thus, the oxygen industry still has a long way to go in supplying the potential demand.

It is worthwhile examining the oxygen usage by the steel industry a little more closely. There are two major phases in the production of steel:

1. Steelmaking from iron ores, through controlled addition and removal of oxygen.

2. Steel forming through heating and/or working requiring oxygen to burn fuels used.

For reasons of economy and tradition, as we have already noted, some 99 per cent of this oxygen is obtained by the use of ambient air.

At present we are well on the road to having mastered the technology of oxygen additions in the steelmaking end. However, as steelmaking technology comes under closer control (along with higher production demands) more and more of the oxygen used will be controlled. Dr. Herty and colleague's work on physical chemistry and Mr. Strassburger's comments on ore beneficiation are some signposts in the direction steelmaking will go.

The second major use of oxygen in fuel combustion for steel forming is hardly in its infancy. There have been a few examples of enriched air furnaces, but the technology has been so little explored that no specific statements can be made. However, there is no question that the greater availability of oxygen in steel plants will accelerate its use in reheating furnaces.

So, in concluding my remarks, I believe that we are only on the threshold of widespread oxygen use in the steel industry. When we meet in ten years and have a twentieth anniversary of the first oxygen papers, such titles as "Control of Steel Quality by Oxygen Control in the Hearth" along with "Reduced Conditioning Costs Resulting from Oxygen Reheat Furnaces" are apt to appear.

Whatever the subject of the papers, it is certain that controlled use of large quantities of oxygen in the steel industry is here to stay.

Dwight C. Brown: This is a very timely and interesting subject in view of the pressure that exists on the steel industry to increase production as much as possible within the framework of existing plant and to utilize new processes with greater productivity per capital dollar. Increased and enlightened use of oxygen in steelmaking will play an important role in this effort as evidenced by the attention given to it here today.

I believe it safe to say, that no one cycle will completely satisfy the multiple needs of an integrated steel plant. That is, no one cycle will be optimum for all needs for oxygen. The cycle decided upon will, at best, represent a compromise in certain areas. The important thing, then, is that the cycle chosen represent the best possible choice based on present and projected needs and that the compromises are made where they can best be tolerated.

It is apparent that these four cycles do not represent all the possible cycles that could be installed. They are four typical cycles of most probable interest to the steel industry. A cursory examination of low temperature techniques and cycles would indicate the number of possible variations to be had and an installation for any one steel producer might have many variations around the general process patterns outlined by Mr. Schilling. An air separation facility can be as tailored as the needs and incentives justify.

I would like to ask Mr. Schilling about some of these possible variations a little later: however, the following process and economic parameters exist for consideration.

1. Capacity.
2. Single or multiple units.
3. Pressure of produced oxygen.
4. Gaseous or liquid oxygen or both.
5. Pressure of cycle.
6. Purity of oxygen produced.
7. Amount and purity of high purity N_2 stream.
8. Consideration of capacity in relation to maximum demand and its attendant implications in storage, both gaseous and liquid.

There are many other considerations in arriving at a tailor-made facility that best meets economically the specific needs of a given steel producer.

Let us review for a moment where oxygen is used in an integrated steel plant and then ascertain the adequacy of these cycles to meet these needs. Several uses have already been adequately treated in this session. The following uses immediately come to mind.

1. Scarfing and cutting.
2. Open hearth decarburization.
3. Open hearth combustion.
4. Blast furnace enrichment.
5. Top blown converter.
6. Miscellaneous cutting and burning.

A potential application is in the direct reduction of iron ores via hydrogen produced by use of high purity oxygen.

Of these, only blast furnace enrichment and open hearth combustion can advantageously use 95 per cent oxygen. All other applications require or prefer 99 per cent oxygen. From another standpoint, that of continuity of supply, we again find these same applications of blast furnace enrichment and open hearth combustion characterized by being able to tolerate wide swings in availability or continuity, essentially from 0 to 100 per cent of plant capacity. Loss of oxygen here means principally some decrease in productivity by virtue of reduced partial pressures of oxygen in combustion. However, expensive storage or reserve capacity cannot usually be justified. Thus the low pressure gaseous oxygen cycle appears to be well suited to this utilization pattern.

The question here then is as much what happens when one or more of a series of blast furnaces goes off as it is what happens when the oxygen plant goes down. Thus the question of economic and process turndown ratio becomes of importance. It is not inconceivable that three out of, say, five blast furnaces will be off for a short time. It is also a usual occurrence that one out of five furnaces will be off for an appreciable period. In the case of the former, can you cut to 40 per cent capacity for short periods? In the case of the latter, can you operate economically at 80 per cent of capacity and less for extended periods of time? It has not as yet been proved that it is desirable or possible to utilize in furnaces all the oxygen made available to them.

In reference to the low pressure cycle, I would like to ask the following questions:

1. What steelmaking applications other than blast furnace enrichment and open hearth combustion is this cycle particularly suited for?
2. What is the composition of the 95 per cent O_2, the 98 per cent O_2?
3. Can such a plant produce oxygen of any purity between 95 and 98 per cent? If so, what changes are required in operation and at what cost?

4. What are the probable variations in O_2 purity and capacity with, say seasonal variations?
5. What turndown is possible processwise and economically?

The medium pressure, high pressure and mixed pressure cycles seem to be particularly suited to that pattern of utilization which requires both high purity and continuity of supply. Where one would install one over the other would seem to depend principally on capacity, need for flexibility, and ratio of peak demand to plant capacity. At this point, I would like to ask Mr. Schilling to expound a little further as to the factors that would dictate the choice of medium pressure vs high pressure vs mixed pressure cycles.

Specifically, with regard to the medium pressure cycle, I would like to ask:

1. Is the main air compressor capable of variable discharge pressure or is one limited to the amount of air put through the expander for variations in refrigeration and therefore in the amount of liquid oxygen produced?
2. Does this cycle lend itself well to modification for the production of high purity nitrogen and argon? If so, at what incremental investment and operation costs?

With regard to the high pressure cycle, I have only one question. What considerations would dictate use of this cycle in an integrated steel plant?

The mixed pressure cycle is of particular interest to me in that a modification of this cycle has been installed at our Aliquippa works for a utilization pattern requiring high purity and continuity and involving scarfing, cutting and top blown converters.

Relative to this cycle, I would like to ask:

1. Can this cycle produce a lower purity oxygen at some increase in capacity and/or decrease in operating costs?
2. For any given installed plant, what variation is possible in production rate of liquid oxygen and at what change in operating costs?

Martin J. Conway: Mr. Schilling's paper serves as an excellent reference for those of us who must evaluate the economics of the various cycles and their adaptability to a specific purpose. The "Comparison of Power Cost" table included in Mr. Schilling's presentation is interesting, in that it compares some of the better known cycle hp per ton per day requirements, showing a range of 25.88 to 47.90 hp per ton per day, or an increase from the 1.00 base to 1.85. This power input item converted to money over the expected life of the oxygen plant, of say, 20 years and 7200 operating hours per year, can readily amount to a difference in power cost of over $4,000,000, with power at $0.01 per kwhr during the period specified.

This power cost differential on a 100-ton per day plant is well worth careful study of the various forms of storage facilities to level off differences between plant output and ultimate usage.

Clarence J. Schilling: In reference to Mr. Brown's first question, that is, "For which steelmaking applications other than blast furnace enrichment and open hearth combustion is the low pressure cycle particularly suited?" I believe that could more easily be answered by someone in the steel industry.

In general, I think it has been pointed out that it is ideally suited for the production of continuous oxygen supply; that is, any process such as blast furnace use where storage is not required because storage of low pressure gas is very costly. I think people like Mr. Strassburger would be much better able to answer what that use might be. Open hearths, of course, would be one example.

Also, any use which by its very nature can substitute air for oxygen, again, would not suffer from a lack of storage.

Of course, this cycle, together with oxygen compression, can again fill the other needs of other cycles through the proper use of surge capacity storage.

As regards the second question: What is the composition of the 95 or the 98 per cent pure oxygen? In the case of the 98 per cent it will be all argon as the impurity. In the case of the 95 per cent, it will depend somewhat on the exact design of the column, but as a general thing it would be about half nitrogen and half argon in the 95 per cent purity.

Question three, "Can a low pressure plant produce oxygen of any purity between 95 and 98 per cent? If so, what changes are required in operation, and at what costs?" Well, actually, the changes required in the plant itself are quite simple—mainly a few distillation trays. More important is the oxygen withdrawal rate, which, if increased when the plant is producing 98 per cent, will gradually produce 97, 96, 95, 94, and finally less dependent upon this withdrawal rate. Oxygen quantities are almost inversely proportional to the purity.

Question four, "What are the probable variations in oxygen purity and capacity with, say, seasonal variations?"

Well, essentially, the answer to that question comes back to the source of the inlet air. As we know, the temperatures in the summer time may be as high as 100 F at the inlet, and in the winter it may be in the area of as low as say zero; so you have 100 F variation in temperature, and a variation of 100 F in temperature will be a variation in absolute temperature from, say, 460 to 560 (degrees Rankine)—and the oxygen production is directly in that ratio; that is, ten parts out of 46, the larger quantity, of course, favoring the cold temperatures.

Again, of course, it is assumed that no adjustment is made in the requirements of the plant, other than using all the air which the compressor pulls in, other things being constant. Purity varies with capacity as outlined above.

Question five, "What turndown is possible processwise and economically?"

Well, this is a question that cannot be answered in a general way. However, with a centrifugal compressor, such as the type illustrated, the normal driver is a steam turbine or an electric motor. If a steam turbine is employed, the compressor, as ordinarily engineered, will have a turndown rate of about 50 per cent of its designed rate. This can be varied somewhat by the design of the blower at additional cost, but normally I would say that that is a round number, and in the case of an electric motor-driven unit, extra impellers and vanes have to be provided to make even this 50 per cent turndown.

But I would say the economical number is on the order of 50 per cent, and a typical oxygen plant will stand this variation in its producing capacity.

Dwight C. Brown: The medium pressure, high pressure and mixed pressure cycles seem to be particularly suited to that pattern of utilization which requires both purity and continuity of supply. Where one would install one over the other would seem to depend principally on capacity, need for flexibility, and ratio of peak demand to plant capacity.

At this point I would like to ask Mr. Schilling to expound a little further as to the factors that would dictate the choice of medium pressure versus high pressure versus mixed pressure cycles.

Clarence J. Schilling: Both the medium and mixed pressure cycles are capable of producing oxygen at pressures from zero to, say, 2500 psi. The essential difference is that the mixed pressure cycle more economically takes advantage of the refrigerating capacity of air. The choice is generally in favor of the medium pressure cycle when the plants are of small size.

For one reason, you want simplicity. Also, small size units are often used in multiple for critical supply of oxygen. The multiple unit becomes a very flexible entity in meeting such critical supply, while, in contrast, the advantage of the larger mixed pressure cycle is enhanced by size.

So, while the choice is not a clean-cut choice, it generally can be said that we would be inclined to supply the medium pressure in plants of 25 tons and under, and probably supply for the typical case the mixed pressure for large plants, 100 tons and over. As you know, our Aliquippa station employs multiple (2) 115-ton units of the mixed pressure cycle.

As for the high pressure cycle, we employ it mainly to produce liquid products, or as a source of auxiliary refrigeration for other process reasons.

Dwight C. Brown; I have just a few more questions that relate both to the medium pressure and the high pressure cycles. I will give them all at one time.

Particularly, with regard to the medium pressure cycle, I would like to ask:

Is the main air compressor capable of variable discharge pressure, or is one limited to the amount of air put through the expander for variations in refrigeration and therefore in the amount of liquid oxygen produced?

The second question relative to medium pressure is:

Does the cycle lend itself well to modification for the production of high purity nitrogen and argon, if so, at what incremental investment and operation costs?

With regard to the high pressure cycle, I have only one question: What considerations would dictate the use of this cycle within an integrated steel plant? I can see it being used by a supplier of liquid oxygen, but it is a little difficult for me to see where an integrated steel plant would use such a facility.

The mixed pressure cycle is of particular interest to me in that modification of this cycle has been installed at our Aliquippa works for a utilization pattern requiring high purity and continuity and involving scarfing, cutting and top blown converters.

Relative to this cycle I would like to ask:

Can this cycle produce a lower purity oxygen at some increase in capacity and/or decrease in operating costs?

Clarence J. Schilling: The first question, related to the medium pressure cycle—is the main air compressor capable of variable discharge pressure, or is one limited to the amount of air put through the expander for variations in refrigeration, and therefore in the amount of liquid oxygen produced?

Well, in the typical cycle (Figure 5) of the medium pressure type, air is normally supplied in a pressure ranging up to 1000 psi. The operating pressure, as I said before, is anywhere from 400 psi up, depending either upon the quantity of liquid oxygen you wish to withdraw or the quantity of oxygen pumped, and to what pressure it is pressurized.

The air compressor, therefore, is able to operate within the limits of 400 to 1000 psi. Many of our plants are continually operating in this range of magnitude. Whenever the air pressure is reduced, obviously the total refrigeration input into the column is reduced, and the amount of high pressure oxygen which can be pumped is decreased, or the amount of liquid that is withdrawn would be decreased.

The expansion engine goes along with the show insofar as it sees only the same pressure that the air compressor delivers. So, it decreases in its proportion of the refrigeration load, the same as the Joule-Thomson valve does its portion. In this particular cycle, the larger proportion of the load is really in favor of Joule-Thomson, so that within limits, the operator can decide that he wants 200 psi of oxygen pressure instead of 1000 or 2000 or 2500. Accordingly, the operating pressure will drop with lower oxygen pressure requirements. If he chooses to make some liquid, the plant has a greater capacity to do so, whenever the pump pressure is less.

Next, "Does this cycle lend itself well to modification for the production of high purity nitrogen and argon? If so, at what incremental investment and operation costs?"

For adaptability, the medium pressure cycle is very adaptable. As a matter of fact, we have some large plants employing this cycle in which quantities—many hundreds of tons of nitrogen—are produced with 99.99 per cent purity simultaneously with the production of pumped liquid oxygen. These plants have additional refrigeration requirements beyond air distillation, and therefore, the power penalty in the attached table (1.22 vs 1.00) is not applicable. The same can be said, however, with regard to the mixed pressure cycle. It is equally adaptable to the production of quantities of nitrogen, but not to the same extent, inasmuch as in the case of the mixed pressure cycle, Figure 9, only a part of the nitrogen is not contaminated by air and water, so that the flexibility exists only in the quantity that you wish to put through the air—or in countercurrent flow to the air coming from the booster side of the cyclic; where these numbers are compatible, either one would do an equal job on nitrogen. For such process reasons, we might wish to vary the proportion of air boosted to high pressure in the mixed pressure cycle.

Neither of these cycles has any parasitic demand on the column by the withdrawal of nitrogen vapor. That can be a variable number, so that both can be suited to the production of high purity nitrogen. By the addition of auxiliary equipment they can both be adapted to the production of argon also.

The question of incremental cost is really too difficult for me to answer promptly, because the amount of ni-

trogen that would be involved at high purity would be one factor, and the amount of argon hoped to be recovered would be another. The investment of the whole plant would vary with both these variables, the number of trays, and the percentage of recovery that was involved.

As to the use of the high pressure cycle in an integrated steel plant, you are correct—it would not normally be used. I have included it here to show the scope of cycles available to the process designer, rather than as a recommendation for application.

On the question regarding the mixed pressure cycle—the first question is:

Can this cycle produce a lower purity oxygen at some increase in capacity and/or decrease in operating costs?

The answer is that for practical purposes the cycle can, of course, make low purity oxygen, as any cycle can, by simply increasing the withdrawal rate. The apparent cost of oxygen goes down—that is, the cost, measured on the basis of the total gas taken off, goes down—but on the volume of oxygen actually contained, it is practically constant.

Question two: For any given installed plant, what variation is possible in production rate of liquid oxygen and what change in operating costs?

Well, again, this has to do with the type of plant that was installed. For example, taking the mixed pressure plant, we will say that we have a low pressure air supply of 85 psi, and we have a booster that is taking 30 per cent of this air and boosting it up on a normal pressure of 500 psi. If it is anticipated that this plant needs to supply quite a bit of liquid storage, the design of this booster would be such that it would operate, again, from this 500-psi level to one to 2500 psi and, the higher the pressure requirements, the more refrigeration that should be put into this booster stream, from which the refrigeration is really coming.

Now, once the plant has been installed, you still have a chance to vary the liquid that may be produced in this way. You may reduce the amount of oxygen that is pumped. This immediately allows you to put more refrigeration into the boosted air, for two reasons: (1) the Joule-Thomson effect of the oxygen is no longer lost, and the effect on the cooling of feed air by outgoing products allows you to do a better job of putting in external refrigeration. Any possible increase in air pressure will enhance both these numbers, so that the thing to do for a plant that is already installed, if you want to temporarily increase its liquid-making capacity, is to reduce temporarily the amount of gaseous oxygen pumped.

Now, a more effective manner, again within the limits of the operator's wishes, is to reduce the amount of low pressure air which is for the time being injected into the plant. This low pressure air is, for all intents and purposes, a parasite from a refrigeration standpoint. The high pressure air provides the refrigerating effect. Consequently, if we reduce the amount of parasite, we will gain by an increase in the production of liquid.

J. H. Strassburger: To answer one of Mr. Brown's questions regarding the use of, say, 95 per cent purity oxygen in addition to open hearth and blast furnace enrichment, this oxygen is being used successfully in lancing through the open hearth doors, and also roof lancing.

In reference to the shutdown in blast furnaces, I think we should answer that question, because we are operating a group of four furnaces. If we have a furnace that has a delay of cast time of five minutes, or even an hour or an hour and a half, we do not usually change the operation of the plant. In other words, you establish certain thermal conditions in the plants, and to upset these conditions, we do not consider it economic to throw our plant out of thermal balance. We will often give additional oxygen to the converter plant if they want it, and dispose of some of it in that way.

Now, as regards a shutdown of a blast furnace for a rework, at the present time we have enough oxygen, and if we were to shut down one furnace, we have a total of 7½ per cent of oxygen available, which is spread over four furnaces.

Well, if we had one furnace down, the very first thing we would do would be to put 2½ per cent in each furnace.

Now, we have successfully taken oxygen up to three per cent and made a 14½ per cent gain in production. At four per cent oxygen we have made 19½ per cent gain, and there is no doubt in my mind that we can go higher than four per cent.

In other words, going from three to four per cent there was no flattening out in the curve. We got exactly the amount of iron that we would expect in going from 24 to 25 per cent oxygen content. So, if we would have a 1000-ton plant—that is, two 500's, 800 tons would give us three per cent on each of four furnaces, and we are planning this additional plant at the present time, so in the future if we had a total of 12 per cent spread over four furnaces, there would be no question in our mind of going to 12 per cent on the three furnaces. As I said earlier, with the same burden, of two and three per cent, this burden went up from 1450 at two 1600 tons a day at three per cent, and 1700 tons a day at four per cent. So we would take full advantage of that shutdown.

T. J. Milhaupt: I would like to comment particularly on Mr. Lambert's paper. While the facts presented are in no way questioned, it is felt that a few comments may be in order by way of clarification and emphasis, primarily for the benefit of those not intimately associated with the subject.

"How much does oxygen cost?" is a question for which there is no simple answer. Mr. Lambert has clearly presented his oxygen plant operating costs and has indicated an optimum cost of 8.69¢ per 100 cu ft at 100 per cent ingot operating level with proportionally higher unit oxygen costs indicated at lower ingot operating levels.

It should be noted, however, that only operating costs are presented and that recovery of mill expended capital funds must be included and considered before comparison is made with a guaranteed price for purchased oxygen produced on-site. Purchased oxygen proposals generally provide for the vendor to perform a turnkey job of supplying, erecting, housing, as well as maintaining and operating the on-site plant; the customer providing only a suitable level site and necessary utilities to the plant load centers. In the case of the oxygen supply system at the J & L Pittsburgh Works, we would estimate that an investment in the order of $500,000 has been made by the works in providing for foundations, building, and plant erection but not including the cost

of providing utilities to the plant site which would be required in any case. If a charge of 24 per cent per annum is made against this capital to cover amortization, taxes and insurance, plus a return on investment commensurate with that expected in the purchase of any similar mill facility, this charge will amount to $120,000 per annum or $10,000 per month. This corresponds to an increment of cost of 1.48¢ per 100 cu ft of oxygen production at the 100 per cent ingot level and brings the full load oxygen cost to 10.17¢ per 100 cu ft.

It is evidently Mr. Lambert's feeling that he should acquire additional oxygen production capacity or liquid oxygen supply to provide continuous supply at the 100 per cent ingot production level in order to be prepared for scheduled or unscheduled plant outages. We think this is a proper conclusion. As the author points out, this additional production would be available for experimental or marginal uses; however, this most certainly adds to the cost of normal oxygen.

A second item of interest is the author's indication that at the end of 15 years, operating costs will be reduced approximately 44 per cent due to the elimination of the lease charge. If the past can be used as a guide to the future, it is likely that costs for labor, utilities and services, will be substantially higher 15 years from now. More important, however, is the certainty that while oxygen plants have a life expectancy greater than 15 years, the cost of maintaining such equipment in its old age will be substantially higher than when new. Still looking ahead, it should be noted that the oxygen industry is not standing still. Very considerable sums are being spent and will be spent in the future in developing new plants of greater efficiency, reduced power requirements, decreased maintenance and minimum operating labor through automation. It would appear, therefore, that it will be difficult to obtain all of the savings at the end of 15 years that are indicated in the author's tabulation.

We certainly share the author's optimism for the continued growth of tonnage oxygen produced "on site" in the steel industry, and on behalf of those of us who are associated with the interesting problem of supplying these oxygen volumes, we would like to thank Mr. Lambert for his contribution to the definition of objectives.

R. A. Lambert: Mr. Milhaupt is certainly correct in stating that there is no simple answer to "how much does oxygen cost." The answer can only be found from an analysis of affected cost factors related to the specific plant for which either purchased or "on site" generated oxygen is being considered. No two plants are similar in oxygen use, including the peak load demands or the capital funds that would be required to install not only the generating equipment but also provide for proper distribution and control of this utility.

Mr. Milhaupt has taken the cost figure from my discussion for the 100 per cent ingot operating level and added to it an increment cost representing investment capital and indicates a total cost of 10.17¢ per 100 cu ft. I have no objection to adding this capital investment to the unit operating cost; however, this was excluded from my discussion for the very reason that I have previously pointed out; namely, that different plants would be required to invest different amounts of capital funds, depending upon their own plant conditions. The Pittsburgh Works, in my opinion, had a satisfactory geographic layout with most of the existing transmission lines in such location that it was relatively simple to apply an onsite generating plant for the needs. I take exception, however, to Mr. Milhaupt's use of the word "optimum" in his qualification of our 8.69¢ per 100 cu ft cost. This is not an "optimum" cost. It is actual cost based on historial operating conditions. We believe that as more experience is gained in operating our oxygen plant, maintenance labor and material will be significantly reduced.

A very important factor in consideration of comparative costs are those obtained under reduced plant operations. When ingot operating levels become low, the "break-even point" is most important. In brief, I would suggest that, in evaluation of oxygen costs, consider most carefully what happens to these costs when the plant oxygen demand drops to about 40 per cent or less of the average demands when the plant is operating full. We believe that we have the most economical arrangement inasmuch as an appreciable percentage of our total oxygen costs are controllable with lower production rates. ▲

California Youth Wins AISE Scholarship

HENRY HALSEY KNAPP III, of Altadena, Calif., has been awarded an Association of Iron and Steel Engineers Merit Scholarship in nation-wide competition. Mr. Knapp plans to major in electrical engineering at Massachusetts Institute of Technology.

The AISE Merit Scholarship program, begun in 1955, is part of the Association's continued program of educational activities, which also includes various lecture courses, special publications, and research work on steel plant engineering problems.

One AISE Merit Scholarship is awarded each year by the National Merit Scholarship Corp. to an outstanding high school senior who desires to study mechanical, electrical, metallurgical, chemical or civil engineering in an accredited college or university of his choice.

Henry H. Knapp III
1958 Award Winner

Methods of Control of Strip Dimensions on Hot Strip Finishing Mills

by R. A. Phillips,
Control Systems
Analytical Engineering Section
General Electric Co.
Schenectady, N. Y.

. . . . to hold finishing dimensions, the hot strip mill must be set up accurately and the stand speed regulated accurately . . . . for this, positioning controls on screwdowns and speed regulators are necessary . . . . some type of automatic set up of both screwdowns and speeds is foreseen . . . .

THE subject of automatic gage control for cold reduction mills has received considerable attention in the past two years.[1,2,3]* The principal cause of thickness variation in the product delivered from the cold mill is the thickness variation in the strip entering the cold mill. The source of these coils is the hot strip finishing mill. An obvious way of improving the product of a cold mill then is to decrease the delivered thickness variation of the hot mill. If less variation in strip width can be obtained as well, a smaller loss will result in trimming operations. This paper relates to methods for closer control of strip dimensions in tandem hot strip finishing trains.

THE IDEAL FINISHING MILL

As a means of visualizing the causes of dimensional variation, consider a tandem hot strip finishing mill rolling under the conditions shown in Table I. Under such conditions there is nothing in the rolling process which deteriorates dimensional quality of the finished strip.

TABLE I

- **Ideal incoming strip**
  - Uniform chemistry
  - Uniform temperature
  - Uniform thickness
  - Uniform width
- **Ideal mill drive**
  - Constant speeds in all stands
- **Ideal mill setup**
  - Correct speeds for drafts taken
  - Low interstand tensions
  - Separating force correct for roll crowns used
- **Ideal thermal conditions**
  - Constant mill housing temperatures
  - Constant roll temperatures
  - Constant strip temperature except at roll bites
- **Ideal roll conditions**
  - Concentric rolls
  - No roll wear

FACTORS WHICH INFLUENCE STRIP DIMENSIONS

Before discussing the finishing train it would be well to review the history of the metal between the slabbing mill and the finishing train. From the slabbing mill, the slab goes into a reheat furnace where in the heating zone it slides along metal skids welded atop water cooled tubes. The usual design is to have four skids which are perpendicular to the direction of rolling. There are then four areas where there is relatively little heat put into the slab. Leaving the heating zone of the furnace, the slab passes through a soaking zone where it slides along stainless steel skids which are not cooled. If left there long enough, the temperature will equalize throughout the slab. It appears that economics dictate a shorter time. As a consequence, the slab leaves the reheat furnace with a temperature profile as shown in Figure 1.

From the reheat furnace the slab goes through either a reversing roughing mill or four roughing stands.

Since the finishing train will take a total reduction in the order of 10 to 1, the entry speed will be considerably lower than the delivery speed of the roughing mill. Sufficient time elapses during entry in this operation to allow a sizable temperature decrease from head to tail to occur. Figure 2 shows the temperature-time profile as seen by the entry stand of the finishing mill. It will be

* Numbers refer to Bibliography at end of paper.

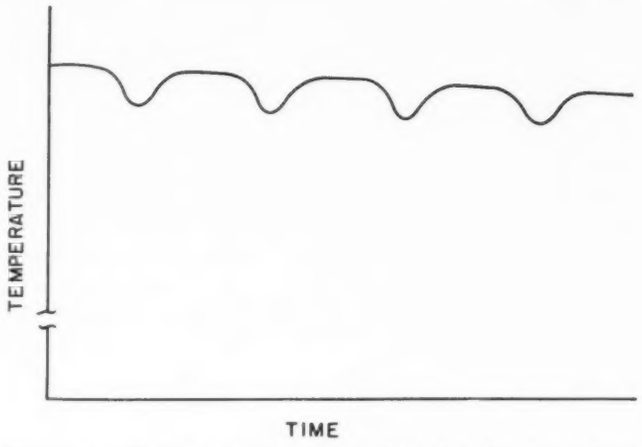


Figure 1 — Temperature profile of slab when leaving reheat furnace is irregular.

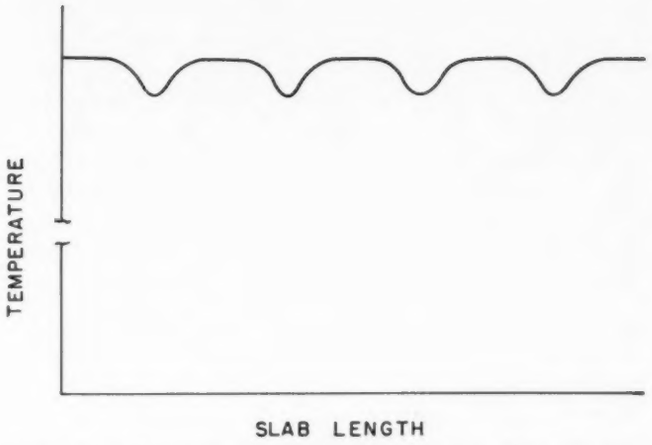


Figure 2 — Temperature-time variation of strip entering first finishing stand shows effect of slab heating.

shown later in the paper that this is the principal input variation of the finishing mill.

In setting up the finishing mill, the operators set the loaded opening between rolls so that each of the stands except the last will take reductions which will result in approximately equal loads on the individual stand motors. The usual practice is to take approximately ten per cent reduction in the last stand so that the delivered product will be correctly shaped. The operators choose speeds for each stand that will give the same rate of mass flow at every point in the mill. The speeds of the stands are also selected to heavily load the stand motors. Indirectly, this means that the delivery speed chosen depends upon delivery thickness and width and the alloying elements in the steel.

If the speeds of each of the stands have not been correctly preselected, the speed operators will see slack or excessive tensions develop between stands as the new strip is being rolled. Using one of the middle stands as a pivot stand, the speed operators will adjust the relative speeds. The range of allowable tensions on hot steel is small indeed. If there is slack between stands, the material will not track properly. At tensions of a very few thousands of pounds per square inch, the steel will creep very rapidly. Even in the short time the steel is between stands it will stretch sufficiently that the strip will change in both thickness and width. There are a number of ways to regulate thickness; but once the width has been decreased by excessive tensions, there is no control variable which will bring it back.

Therefore, to be effective, all of the methods of controlling strip dimensions require that stand speeds be held accurately to the value desired since small speed differences produce sizable tension changes. Although with the use of auxiliary field windings a motor may be made to have zero regulation at full load, it does not normally have zero regulation at intermediate loads. The regulation of a motor is also affected by variations in commutation which produce an effective brush shift. Thus, there is a trend toward the use of speed regulators on hot strip mills.[4] It is easier for operators to maintain low tension throughout the strip when speed changes can be made quickly and speeds accurately held.

It follows that the possibility of reducing dimensional variations is dependent, first of all, upon accurate mill setup. Screw-down position regulators using numerical control now available will enable an operator to position screws with greater accuracy than practical using time-consuming rotary switch control. One operator can initiate positioning of any number of stands simultaneously. Going a step further, the operator's fallible memory can be replaced by perfect memory by using punched card systems or permanent magnetic storage. We expect that eventually a computer will be included in mill setup equipment to calculate optimum settings.

Whenever the mill is shut down for roll changes or maintenance, there are dimensional changes in the mill which produce changes in the unloaded roll opening. A highly reliable roll force measuring device is necessary so that the position regulator can be zeroed. The procedure is to bring the rolls together until roll force equals a reference value. This is the zero from which all roll openings are set. This procedure used with stored settings will produce consistent mill setup.

RESPONSE OF MILL TO A TEMPERATURE VARIATION

It has been stated previously that the temperature variation over the length of the strip entering the finishing train is the principal input variation. Each mill stand sees this temperature variation successively as a variation in the strip's resistance to deformation. It is assumed that each stand sees an equal percentage change in the resistance to deformation. Before it will be possible to follow a "cold spot" through the mill, some time should be spent on the fundamental physics of the rolling process. In this paper, work roll flattening will be neglected. When considering the effects of temperature variation, it will be assumed that there is no thickness or width variation in the strip as it enters the first finishing stand.

There is one concept which must be accepted before any theoretical discussion of rolling mill behavior can proceed. That is, the concept of a neutral point. It has been a common assumption in many past papers that a vertical plane cross section of strip remains plane during rolling. For this condition there will be but one point on the roll arc of contact where the strip velocity equals the roll velocity. If the rolls are to grip the strip, the neutral point velocity must be greater than the entrance velocity and less than the exit velocity. For this paper, backward slip is defined as the difference in entrance and neutral velocity; in per cent of neutral velocity;

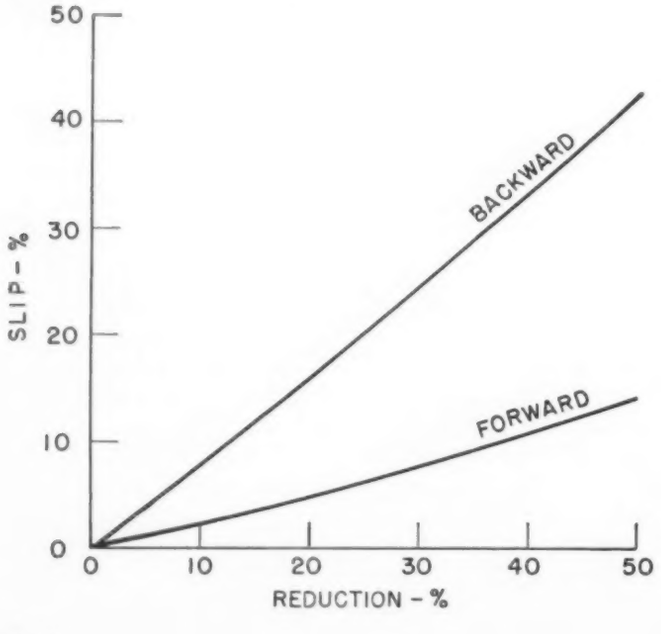
forward slip is defined as the difference in exit and neutral velocity in per cent of neutral velocity.

Figure 3 is the calculated plot of forward and backward slip vs reduction for the condition that input tension in psi equals output tension in psi using the calculation procedure of one paper.[5] Although the curves are not exactly the same for all entry thicknesses, the calculations show that, for entry thicknesses in the range of 800 mils to 100 mils, the slip is within 1.3 per cent of that shown by the curve.

The perfectly stiff mill—First consider that the mill stands, screws and rolls are perfectly stiff (although total roll force may change there will be no change in work roll separation). Under this condition the pressure at each point in the roll bite will be increased by an amount porportional to the increase in the resistance to deformation. There will be no change in the location of the neutral point. It follows that the entry and exit velocities will not change so there will be no tendency for the interstand tensions to change.

The mill with spring—In fact, however, the mill stands, screws and rolls are not perfectly stiff, but they will spring apart to furnish the increased total force required to reduce the harder material. Suppose the mill has been rolling strip at uniform input thickness and temperature. Now a cold spot in the steel enters the first stand. For a given entry speed, a cold spot has a definition in time as well as length. Consider that the cold spot is short compared to the transport time between any pair of stands. The increased hardness at the cold spot causes the rolls to spring apart. There will then be a decrease in reduction in the first stand and, per Figure 3, the forward slip will decrease. The exit velocity of the first stand will thus be less than the entrance velocity to the second stand, and an increase in tension will begin to develop between the first and second stand. The spot in the strip which is colder than the rest of the strip is now thicker also. Until the cold spot reaches the second stand, the entry thickness to it is unchanged. The increased tension between the first and second

Figure 3 — Curves give relationship between forward and backward slip and reduction.



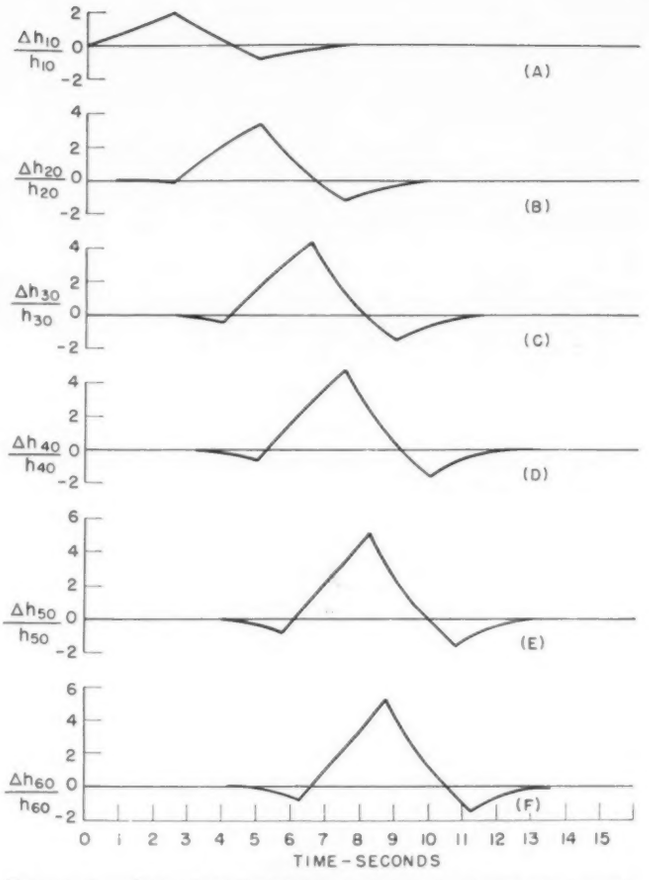


Figure 4 — Calculated thickness from each stand due to triangular strip hardness variation of 15 per cent.

stands aids the second stand in taking reduction. The second stand roll force requirement is lessened, and the work rolls spring closer together. This produces a somewhat thinner product out of the second stand before the cold spot actually gets there.

As the cold spot with its associated increased thickness reaches the second stand, the stand is required to reduce material which is both harder and thicker. Hardness has the dominant influence and there will then be a decrease in reduction in the second stand. Both forward and backward slip will decrease. Therefore, the entry velocity of the second stand is greater than the exit velocity of the first stand, and an increase of tension will develop between first and second stands. The tension between the second and third stands also tends to increase. The tension between stands 1 and 2 results in a decrease in thickness out of the first stand, even though the cold spot has already passed through it. Tension between stands 2 and 3 results in a decrease in thickness out of the third stand before the cold spot reaches it.

As an example consider that strip 60 in. wide and 800 mils thick is reduced to 87 mils in six finishing stands at a delivery speed of 2300 fpm. Figure 4 shows the calculated thickness profile at each successive stand for a cold spot represented by a triangular hardness variation of 15 per cent peak magnitude and, at the delivery speed of 2300 fpm, has a base 5 sec wide. The drafting pattern is such that the successive interstand transport times are 2.5, 1.5, 1.0, 0.75, 0.50 sec. It is assumed the stand drive motor speed changes are negligible and that the deformation of the strip due to tension between stands

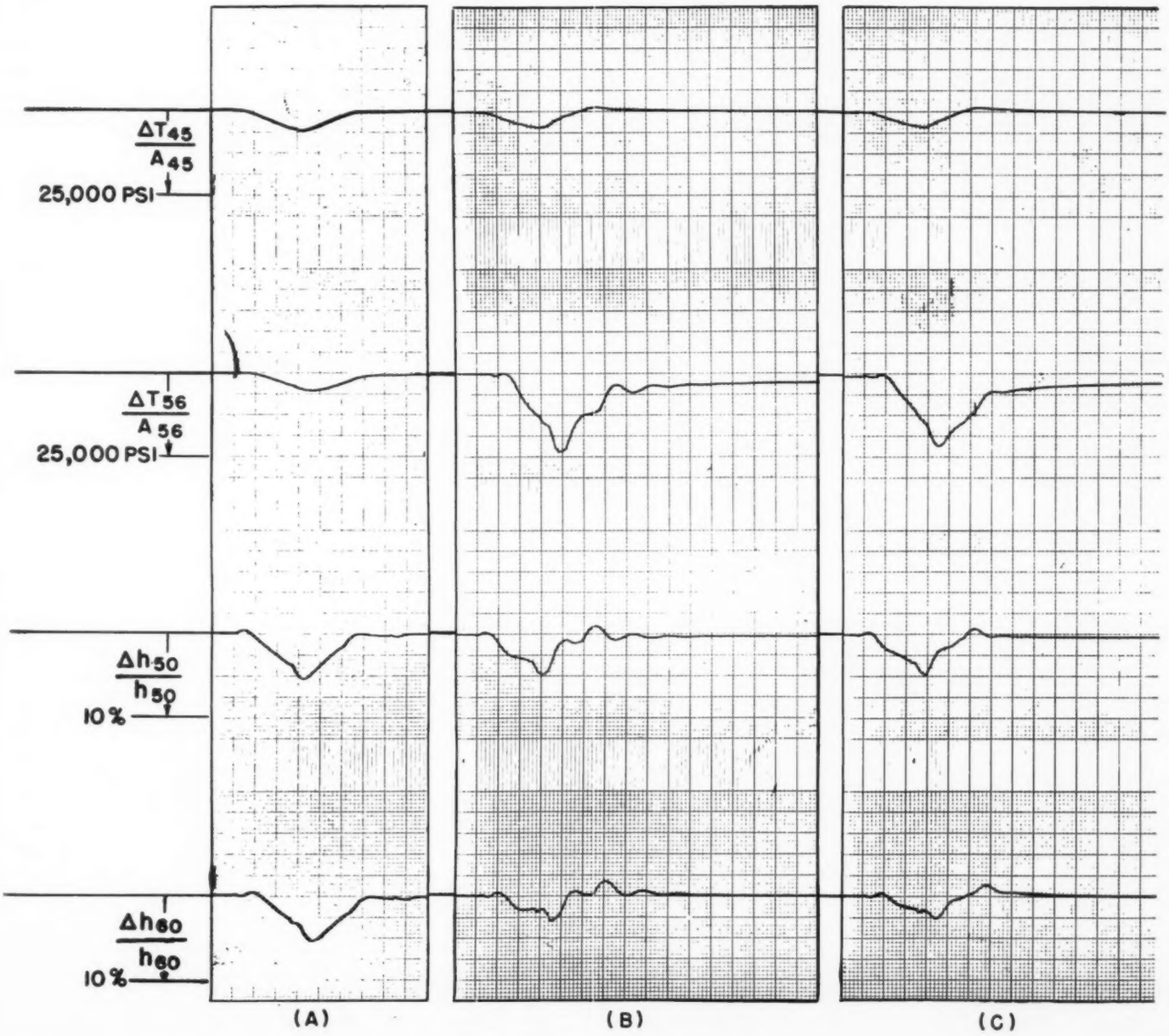
is negligible. It can be seen that there is a tendency for the strip delivered from each stand to get thinner than nominal before the cold spot reaches it and not fully recover until sometime after the cold spot has left. The equations from which this and subsequent calculations were made are similar in form and were developed in the same manner as described in a paper on the tandem cold mill by this author.[2] Differences in the equations result from different conditions for plastic flow in the roll bite for hot and cold rolling. For these equations the roll bite analysis for hot rolling by R. B. Sims[5] was modified to include effects of incoming and outgoing tension.

EFFECT OF HARDNESS ON WIDTH

In the calculation of the profile shown in Figure 4 it was assumed that there was negligible strip deformation between stands. It was then found that there is a tension increase which accompanies the cold spot and that effects of this tension increase are in evidence ahead of and behind the cold spot. It is known that creep rate increases with tension and temperature. Therefore, the tension increase produced by the cold spot results in the material between stands necking down in width and thickness to some degree. The material adjacent to the cold spot is hotter and necks down more. If the temperature variations are large, the width variation will be large. Once a width variation appears there is no control variable which will remove it. However, if the temperature variations are kept small, there will be negligible interstand strip deformation and the method of calculation described above is valid.

As the strip passes through each stand in the finishing train, it loses heat to the work rolls. The total temperature drop is about 250 F in the mill. As the term implies, "creep" is a time phenomenon. When the strip is passing between the early stands it is hotter and the strip transport time is longer; therefore, the tendency towards creep is much greater than in the later stands. It can be expected then that the major width variation is introduced between the early stands.

Figure 5 — Curves give results of analog computer study.



RESPONSE OF MILL TO THICKNESS VARIATIONS

Up to this point variations of strip thickness at the entry to the first stand have not been considered. There are two principal types of strip thickness variation out of the roughing mill. The mean thickness from strip to strip will vary if the roll openings for the successive passes are not set consistently. The development of numerical roll positioning equipment and stored programs makes it possible to minimize this type of strip thickness variation. The second type of thickness variation is the result of the cold spots passing through the roughing mill. Since mills are not presently equipped with thickness gages at the delivery of the rougher, these variations are not measured. Since the roughing mill looks like a stiffer mill to the strip than does the finishing train, it is reasonable to expect that, as an outside figure, thickness variation leaving the rougher is no greater than the 5 per cent thickness variation leaving the finishing train as shown in Figure 4. A 5 per cent variation in thickness into the finishing train will be assumed in the discussion.

The perfectly stiff mill—First consider that the stands of the finishing mill are perfectly stiff. When the thicker strip enters the first stand, the stand is forced to take a greater reduction and, per Figure 3, the forward slip increases. The exit velocity of the first stand will thus be greater than the entry velocity of the second stand and the tension will tend to decrease. The decreased tension between the first and second stand produces an additional effect. Since there is less back tension, the strip will try to speed up with respect to the rolls. This is an increase in the forward slip. The exit velocity of the second stand will thus be greater than the entry velocity of the third and tension between them will decrease. As would be expected this trend continues, diminished, down the mill. That is, a sustained increase in thickness of strip entering the finishing train produces a decrease in interstand tensions throughout the whole train while the amount of decrease diminishes down the mill. A thickness variation which results from a cold spot will be transitory in nature and will produce temporary tension decreases which progress through the mill with the cold spot.

The mill with spring—Now consider the effect of mill spring. When the thicker strip enters the first stand, the work rolls spring apart. The change in reduction is not so great as in the case of the perfectly stiff mill. The increase in exit velocity of the first stand is less and the tension decrease between the first and second stands is less. It would be expected that the remaining tensions in the mill would change proportionately less if it were not for the fact that the exit thickness at the first stand increases in a mill having spring. This thickness increase will now be followed through the mill.

The stands will attenuate a fractional gage change, that is, the percentage increase in output thickness is less than the percentage increase in input thickness. Therefore, the second stand will tend to take a greater reduction than before. The contribution of the entry thickness change of any stand when considered alone will be to decrease the entry velocity and increase the exit velocity. This tends to produce a further tension decrease. Therefore, in a mill with spring, sustained increase in entering thickness produces a lesser tension decrease between the first and second stands than in a perfectly stiff mill. Depending upon the actual value of the mill spring, the amount of tension decrease may or may not diminish down the mill.

It is interesting to examine the calculated tension changes resulting from a 5 per cent sustained thickness increase to the first stand for the same schedule as described earlier. It is assumed that all the stand drive motors hold constant speed. The maximum tension decrease occurs between stands 5 and 6 and is 950 psi in magnitude and the delivered gage would increase 1.3 per cent. Compare this delivered thickness variation with the 5 per cent shown in Figure 4F as the expected delivered thickness variation due to a cold spot passing through the finishing train. It can thus be expected that the requirements for a regulating system to compensate for strip temperature variations introduced into the finishing train will be more than adequate to compensate for the strip thickness variations introduced.

CORRECTION OF EFFECTS OF TEMPERATURE VARIATIONS

Consistent mill setup and accurate regulation of mill drive motor speeds are basic to any plan for producing strip of improved dimensional quality. The problem of the effects on dimensional quality of temperature variations in the strip must be solved in some other way.

Basically, there are but two ways to minimize the effect on strip dimensions caused by temperature variation. One choice is to reduce to a small value the temperature variations, strip-to-strip and within a strip. This eliminates the cause. The second choice is to use thickness regulators acting to change roll pressure. This eliminates the effect. The choices were put in this order since, from a fundamental engineering standpoint, elimination of cause is the first choice. Economics in a particular situation may dictate elimination of effect to be a better choice.

Temperature variations appear to the mill as hardness variations. It was shown earlier that if the mill were perfectly stiff these hardness variations would produce no thickness variations. What is more important is the fact that no interstand tension variations will be produced by the perfectly stiff mill. Such a mill then should roll strip of uniform thickness and uniform width.

The question then arises. Can a perfectly stiff mill be realized in practice? By definition, a perfectly stiff stand is one in which a change in roll force produces no change in work roll separation. A regulator acting quickly to change roll pressure of a stand to hold thickness delivered from that stand constant fits this definition. Any stand so equipped would behave as a perfectly stiff stand. A finishing train consisting of six such stands would be a perfectly stiff mill. Since the tension changes between stands will be very small in such a mill, there will be practically no coupling between stands; therefore, no regulating system problems are expected.

If less than six of the stands are made stiff in this fashion, some of the interstand tensions will vary considerably. These tension variations can be minimized by varying the stand speeds in addition.

If temperature variations from strip-to-strip and within a strip can be reduced to a small value, a control

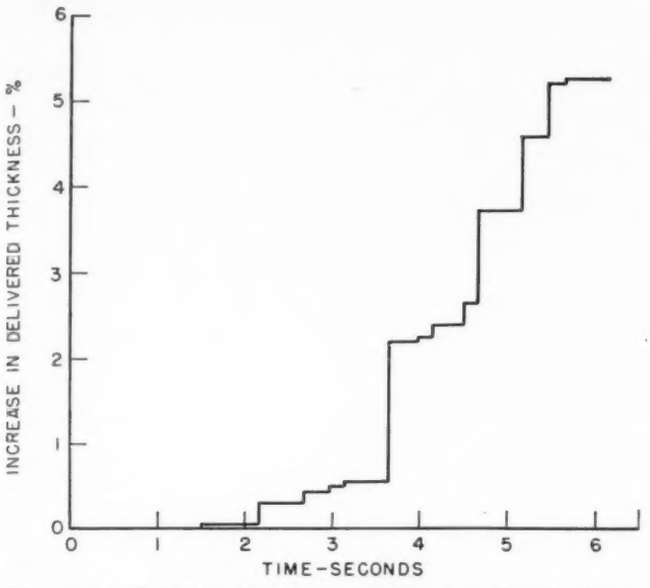


Figure 6 — Calculated delivered thickness of strip from time tail drops out of first stand.

system working through tension becomes feasible. It may be desirable, as in a tandem cold mill, to use screw-down control at an early stand in combination with tension control between later stands. The amount of help in holding delivered thickness afforded by screw-down control on an early stand will probably be much less than on a tandem cold mill because of the tendency for the cold spot to grow back in.

ANALOG COMPUTER STUDY

It was known from previous cold mill gage contro studies[2] that tension control presents some problems in regulating system stability. It was found desirable to make a study of the behavior of this type of control when applied to a hot strip mill. This study was made utilizing an electronic analog computer.

For the analog computer study, the same rolling schedule and 15 per cent triangular variation of hardness was used. To avoid setting up the six-stand mill in complete detail, certain simplifying assumptions were made. The speeds of stands 1 through 4 were assumed to be held constant by speed regulators. It was thought that interstand tension changes in the early stands caused by speed changes in the later stands would be quite small. Accordingly, although all changes in tension were represented, the secondary effect of the interstand tension changes on thickness in the first three stands was neglected. It follows that the profile entering the fourth stand will not be altered by the action of the tension control. This then was considered an input. This thickness profile of Figure 4C is shown to be a distorted triangular function. For the analog computer study it was assumed to be triangular with a 4 per cent peak amplitude and a 5-sec base. It could then have the same shape as the hardness variation and could be generated by the same function generator. Figure 5A shows the thicknesses out of stands 5 and 6. They have the same peak amplitude as the corresponding traces of Figure 4. The principal difference is the lesser amount of distortion in Figure 5A due to the simplification of the input. The study of regulating ability should be just as valid however. In addition to thickness variation, Figure 5 shows tension between stands 4 and 5 and between stands 5 and 6.

Figure 5B shows the effect of using the output of the x-ray gage located on the delivery side of stand 6 to control the speed of the stand 6 motor through its speed regulator. Figure 5C shows the effect of using the thickness deviation at the stand 6 roll bite to control stand 6 speed, thus avoiding the transport lag. The increased stability of Figure 5C indicates that the system could be run at a higher gain thus reducing thickness deviation even more.

Comparison of the runs taken under the different conditions shows that:

1. On a hot strip mill there is considerable merit from a regulating system standpoint in obtaining the error signal for the gage control from the roll bite.
2. The tension values shown without control in Figure 5A are sufficiently high to produce some amount of width variation. Thus, temperature variation in the coil must be reduced to permit the superimposed tension increase caused by regulating system operation without affecting width.

THICKNESS PROBLEM AT END OF STRIP

Thus far it has been assumed that strip is in all stands of the mill. Since there is some interstand tension during this time, a problem is created when the strip leaves the mill. When the strip leaves the first stand, tension is lost between it and the second stand. Since there is less back tension at stand 2, the strip will try to speed up with respect to the rolls. The exit velocity of the second stand will thus be greater than the entry velocity of the third and tension between them will decrease. The result is that delivered thickness from each stand will increase. This trend continues, diminished, down the mill. As the strip leaves each stand successively, the process is repeated.

For calculation purposes it was assumed that the interstand tensions prior to the strip leaving the mill were all 4000 psi. Figure 6 shows the calculated thick-profile of the tail end of the strip as delivered from the last finishing stand. Time zero is taken at the instant the strip drops out of the first stand. It is probable, in actual practice, that the mill is set up with somewhat lower tensions than the above between the early stands and somewhat greater tensions between the later stands. The resultant curve would start more slowly and rise more rapidly as strip leaves the later stands.

It is improbable that zero tension can be maintained in the strip preceding the tail end. It is impossible to apply tension to that portion at the extreme end which is shorter than the spacing between two adjacent stands. The logical approach to holding the extreme tail end length to minimum thickness deviation is to change the roll opening in the early stands as it passes.

SUMMARY

It has been brought out that the necessary requisites of any program for holding finished dimensions of hot strip are that the mill be set up accurately and the stand speeds be accurately regulated. This requires positioning controls on the screwdowns and speed regulators on the stand drive motors. Eventually some type

of automatic setup of both screwdowns and speeds is foreseen.

The principal cause of dimensional variation in delivered product is temperature variation in the incoming strip while incoming thickness variation is secondary. The temperature variations must be reduced at their source, or the effects must be reduced by regulators acting to change roll pressure.

It is hoped that this paper will make it possible for user and manufacturer alike to understand better their common process and systems problems. This better understanding should not only assist in improving rolling mill practice but also guide the design of logical process control systems.

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Discussion

PRESENTED BY

THOMAS A. BLOODWORTH, Supervisory Engineer, Electrical Application Dept., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

R. P. SCHULER, Superintendent, Cold Strip Mill, Inland Steel Co., East Chicago, Ind.

O. C. GOCHENOUR, General Foreman-Maintenance, Jones & Laughlin Steel Corp., Aliquippa, Pa.

R. A. PHILLIPS, Control Systems, Analytical Engineering Section, General Electric Co., Schenectady, N. Y.

Thomas A. Bloodworth: We, as a company, have, over the past several years, preached the gospel that the hot strip mill is the place to attack gage control problems rather than the cold mill. Mr. Phillips has presented an excellent paper showing some of the reasons why we have variations in gage in the hot strip mill. He has pointed out one method, with several variations, of attacking the problem.

As he points out in making these studies, it is necessary to simplify the problems or you run out of elements on your computer. However, unfortunately, on your operation you cannot simplify it that much. The problem is there. I remember an incident, here a few years ago when our late chief engineer, Mr. Montgomery, was delivering a paper on "WK^2 Control for Temper Mills." After he got through pointing out the additional control equipment required, one gentleman got up and said he thought this modern control was getting too complicated. As far as he was concerned, he had rolled without WK^2 for twenty years and he would just as soon go on doing it. We would all like to do that, but the problem is still there.

Fortunately for the computer room, we can simplify it by leaving out roll flattening and other complications. These omissions are not possible when rolling and, for optimum results, must be compensated for in the controls.

For that reason we have taken a different approach, and have gone beyond Mr. Phillips' suggestions here. We feel that in order to hold constant gage, you have to go beyond a stiff mill, that even if the mill was stiff there are other variations that Mr. Phillips has not brought in that would affect gage. We think that you also have to operate on the screws; we feel that motor speed control is required, not speed regulation. In motor speed regulation you think of holding the motor speed constant. We do not think you can have the ultimate in automatic gage control on a hot strip mill by that method. We should have motor speed control, not motor speed regulation. And by so doing, we think we can get a flat strip coming out of the hot mill and we will thereby simplify the problem of constant gage on the tandem cold reduction mill.

R. P. Schuler: Mr. Phillips has done a fine job of putting over a very technical and complicated theory to the group. From my experience in the hot strip mill, I do not believe the principal cause of the cold mill's trouble is in the hot mill. The hot mill may contribute, but the cold mill would continue to have off gage material even if the hot mill rolled perfectly uniform bands with no gage variation.

Mr. Phillips mentions preloading the finishing stands and setting up the mill from this point. At Inland we set up from a set of templates or feeler gages. This method has proven the best since it gives us less off gage material and shorter downtime on roll changes. We have tried other methods such as strain gages or settings from the screw-down overloads and have found that our present method of setting up the mill has reduced maintenance on the screw-down assemblies in addition to the other advantages mentioned.

I would like to question Mr. Phillips on his remark that the major deviation or variation occurs in the first stands. I think since the piece is heavier in the back mills there would be less tendency to neck down or creep. For example, if we use the 10 to 1 reduction Mr. Phillips refers to, with a 40 per cent reduction at the first finishing stand, the section should be about six times as heavy at this point as is the finished section. With a given amount of tension in this instance between the first two finishing mills, there would be less tendency to creep than with the same amount of tension between the last two stands even though the temperature is lower between the last two passes.

O. C. Gochenour: I would like to speak for a few minutes from a maintenance standpoint regarding Mr. Phillips' fine paper.

When it comes to the development of controls, which must have been the author's ultimate purpose for this study, I think that the compensation control for the thickness increase in the tail end of the strip is by far the most important consideration. With respect to variations within the length of the strip, I think that simplicity should be of the essence in the control. There seems to be a tendency to complicate the automatic

gage control systems and this I think is causing, unnecessary hardships on us maintenance people.

I would certainly appreciate something more simple for the hot mills than has been previously proposed and built for cold mills.

On the other hand, I think we are growing up in quality control, and we maintenance people are going to have to grow with it. We started off with tin plate shear line automatic rejecting equipment, then went back to the cold mill with automatic gage control. Now we are entering into a new era of controlled quality with hot mill gage control, and through the use of mass spectrometers, even open hearth metallurgical control. I think that we have a lot to gain by working in these two areas which have been the sources of many quality troubles and I expect to see better quality strip coming forth in the future.

R. A. Phillips: I did not intend to raise a question in the reader's mind with my use of the term "speed regulator" rather than "speed control." I agree that stand speeds must be varied to achieve automatic gage control in some cases. This can be done quickly and accurately by introducing a speed reference change into the speed regulator.

I hope that the analysis mentioned by Mr. Bloodworth as the basis for his differences in opinion will be the subject of a future paper.

In regard to the first remark by Mr. Schuler, there are a number of strain gages now available which are mounted in pressure blocks rather than on mill housings as in present installations. We believe that these new load cells (as they are commonly called) are superior, especially if equipped with automatic zero adjusting means. They will permit screw calibration while running light. This is not possible using feeler gages and may save time.

In reference to his second comment, I think that the use of the term "tension" in two different ways, in two different dimensions, may have led to a misinterpretation. I think Mr. Schuler and most operating people normally think of tension in total pounds. Throughout the paper I have used the term "tension" in psi.

The changes in interstand tensions expressed in psi, resulting from a cold spot, are roughly equal between each of the stands. Since the creep of the material between stands is dependent, not only upon tension in psi, but also upon the temperature of the strip and the period of time that a particular increment or length of strip is under tension in each of the cases under consideration, the strip will stretch more easily and there will be more time to do so between, say, the first and second and the second and the third stands than it does later in the mill.

Since the change in tension in psi is equal, it follows that the total tension (lb) between stands one and two produced by a cold spot will be the order of six times the tension between stands five and six.

In regard to the questions of Mr. Gochenour, this study did take considerable time, about two years. He said that he would like a simpler control on the hot mill than he sees on the new gage controls for the cold mills. This is a laudable idea, but the only simpler control I can suggest is no automatic gage control.

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Pictorial Roundup

AISE
Spring Meeting

The Dinkler–Tutwiler Hotel
Birmingham, Ala.
April 21, 22, 23

The Board of Directors, District Secretaries, and Staff of the AISE gathered for dinner (1) April 20 preceding the opening of the Spring meeting.

Registration (2) totaled 602 including steel men from Canada and Mexico.

Members of the Combustion Session are shown in (3). Seated are R. A. Lambert, D. C. Haney and R. J. Demaison. Standing are David Cousley, R. W. Ewalt and E. W. Garvin, Jr. Shown in (4) are members of the Rolling Mill Session. Seated are Louis Such, A. L. Thurman, L. S. Mobley and F. G. Kredel. Standing are B. G. Harmon, Robert Hartenstein and R. V. Proctor. Another Rolling Mill Session group is shown in (5). They are from left to right: C. W. Barrett, E. B. Russell, J. M. Dugan, Alfred Krause and D. H. Samson. Mr. Dugan is shown in (6) presenting his paper, "The Application of Progressive Induction Heating to Forged Roll Hardening Operations."

The chairmen of the Off-The-Record Rolling Mill Panel Discussion are shown in (7): Louis Moses (left) and D. C. Horsman. Participating panel members were (8) E. L. Shepherd, C. S. Lambert, E. H. Hollenback and G. R. Neff. In (9) are A. L. Roberts, R. P. Schuler, M. O. Smith, Jr., G. M. Esler and E. H. Forsstrom. In (10) are A. E. Cichelli, C. E. Pritchard and G. R. Neff. In (11) are D. W. McLean, D. A. Lennox, Jr., A. H. Griffiths and F. G. Kredel.

The technical sessions were well attended as shown by the group in (12).

The reception for the Speaker's table guests preceded the banquet on Tuesday, April 22. Shown in (13) are H. P. Bigler, President, Southern Electric Steel Co.; J. E. Urquhart, President, Woodward Iron Co.; and H. B. Johnson, President, Atlantic Steel Co. In (14) are Emil Kern, Vice President, Allegheny Ludlum Steel Corp.; B. C. Blake, Vice President, Connors Steel Div., H. K. Porter Co., Inc.; and W. R. Bond, Vice President-Operations, Woodward Iron Co. In (15) are C. W. Barrett, District Manager, Southern District, Republic Steel Corp.; Leonard Larson, Chief Engineer, Republic Steel Corp., and President of AISE; N. C. Michels, Vice President of Engineering, Tennessee Coal and Iron Div., United States Steel Corp., guest speaker.

The banquet (16) was attended by 420 registrants.

An inspection trip (17) to the Republic Steel Corp., Southern Steel District, Gulf Steel Works, Gadsden, Ala., plant concluded the conference on Wednesday, April 23.

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The Forming

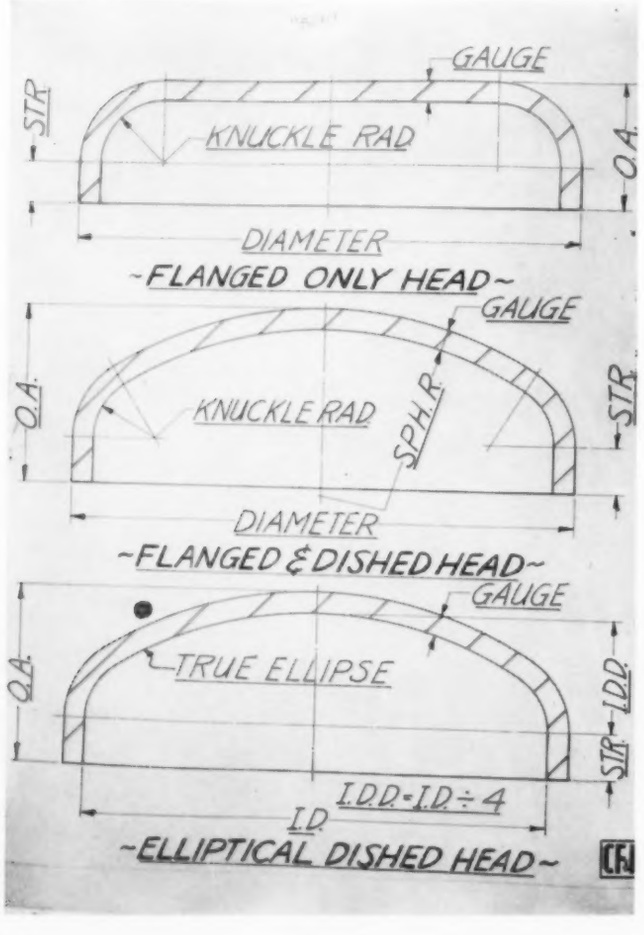
THIS paper, except for a short reference to press work at its close, will be directed to the production of flanged heads by spin-flanging on special machines. The flanging process at C.F.&I's Claymont plant utilizes heavier metals from $^{3}/_{16}$ to 6 in. or more thick, limits being dependent upon shape and diameter required. This is a different process from lathe spinning which is generally confined to gages of $^{3}/_{16}$ in. or under.

Historically, flanged heads have held a significant place in industry from the early days of our country and, up to about 1885, flanging was done first by hand then followed by progressive press flanging. In fact, some extreme sizes and shapes are still produced in that way.

Flanged heads were originally used almost entirely as boiler heads and were of the type known as flanged only. As time passed, wider usage and the restrictions introduced by greater pressure and higher temperature requirements of the completed vessels culminated in the growth of a variety of codes. As each difficulty and new requirement was encountered specifications were revised until now the ASME Code covers all types of flanged heads.

Heads are now available in practically any conceivable shape and those regularly produced are: *Flanged Only, Standard Flanged and Dished*, having a fixed knuckle specification of three × thickness with a dish radius equal to diameter, and, a third type, *ASME Flanged and Dished* having a knuckle of the greater of three × thickness or six per cent of diameter with a dish radius not greater than diameter. Common also are semi-elliptical with a depth of dish equal to one-fourth inside diameter, hemispherical, conical, reverse flanged and dished, flared and dished and shallow flanged and dished. Figure 1 shows cross sections of three types of flanged heads.

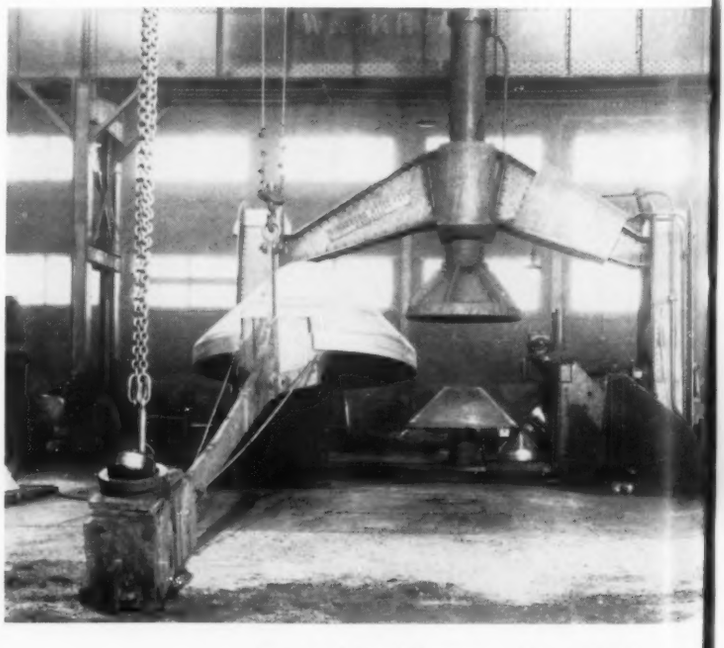
Figure 1 — Three common types of flanged heads are shown in sketch.



The need to eliminate stresses that caused failures around the sharper knuckles then in use resulted in 1927 in the first major revision of ASME specifications for flanged and dished heads. The new requirement was, as above noted, that knuckle radius be the greater of three × thickness or six per cent of diameter. This change gave rise to inability to spin the large knuckle in the specified thickness and necessitated that a greater thickness than formerly be used. At about the same time and similarly for the purpose of elimination of stresses, the semi-elliptical head came into use and we at Claymont produced the first of these for design testing by one of the major oil refineries. The semi-elliptical head provides the practical answer to many needs. It eliminates the objectionable shape of the dished head and the higher cost of the hemispherical heads. It allows for lighter gage due to its greater strength and better contour, and most importantly, it eliminates stresses which is especially essential in pressure vessels for refinery use that must withstand great pressure and high temperature while confining hazardous liquids.

Flanged and *flanged and dished* heads in standard as well as special shapes are, of course, utilized in many machine and mechanical designs other than boiler, tanks and pressure vessels. This has contributed in no small measure toward the requirement for and attainment of closer tolerance on contour than believed possible just a few years ago.

Figure 2—Unit shown can flange heads up to 236 in. in diam.



# of Flanged and Dished Heads

by H. S. Beers,
Superintendent Flanging Dept.,
Wickwire Spencer Steel Div.,
The Colorado Fuel and Iron Corp.,
Claymont, Del.

. . . . manufacture of heads is still very much of an art . . . . method can be applied to many metals and alloys . . . . spinning provides great flexibility, while for large runs a press may provide more economical production . . . .

Important also is the fact that a head designer is not in any way limited in size range. The machines are extremely flexible in operation, dies are not required as in pressing, and a 119 or 121-in. head is as readily produced as the 120 in. diam which is considered a standard size. So too, semi-elliptical heads in standard sizes up to 120 in. are produced on true semi-elliptical shaped dies, while intermediate sizes and sizes over 120 in. are produced from standard spherical dished dies. For example, a 144-in. semi-elliptical head formed over a 126-in. spherical radius dished head die, and a 25-in. radius knuckle die, is well within the code tolerance for a semi-elliptical head.

The following data will particularize on the facilities at Claymont. The production of the circular steel blank is a routine rolling operation of many steel mills. We regard flanging as a specialty and, apart from pressed heads, supply a good portion of the market. Organizationally, flanging is an operation distinct from the standard steel mill operation.

Equipmentwise, we have three flanging machines with a capacity range from $^{3}/_{16}$ to 6 in. in thickness and 9 in. to 19 ft diam. All three machines are similar, although different in size, and are electrically operated having a hydraulic center ram for clamping and forming the dished center portion, while the outer perimeter is spun to shape. A few facts concerning the equipment itself, the capacity and operational procedure of the largest machine may be of interest at this point.

A 500-psi pressure system provides hydraulic power and produces 233 tons at the die. Power for the main drive comes from a 250-hp motor and auxiliary needs are supplied by six motors of 2 to 30 hp. The diameter capacity is 236 in. and depth clearance from clamping cylinder to die spindle is 127$^{1}/_{2}$ in. Figure 2 is a view of this flanging machine.

The forming procedure for an elliptical head, is first to furnace heat to 1800 F. Conveyance to furnace and machine is by a 10-ton double-trolley overhead crane, with resort to two cranes joined by spreaders for extremely heavy items. Four centering arms spaced 90 degrees apart around the spindle, and equidistant from the center, close in to center the material on the die and it is then clamped between flat top and bottom dies. Since the hydraulic ram is stationary and the die spindle rotates, a roller bearing swivel box is mounted between the ram and top die. The blank is then rotated, the die spindle having a variable speed from 34 to 85 rpm giving a surface speed of about 1800 fpm in passage between the forming rollers.

To eliminate the buckling tendency inherent in reducing the outer perimeter of the circle on the first operation, the inner forming die is a stationary cast iron block. After it is reduced sufficiently, the material is reheated and the dies are changed to spherically dished or semi-elliptical shape to provide final dishing and finishing. During this part of the operation, the cast iron block is replaced by a forming block contoured to the desired shape of the knuckle of the finished head. This roller is manipulated into desired position by horizontal screws at the side of the machine and rotates by friction against the head. The outer and forming roller is straight. It is movable vertically and horizontally, and, being mounted in a curved segment, full arc movement is also provided. All movements are controlled by screws manipulated by the operator, giving him complete control and facility to produce any desired contour. As the circle is reduced in diameter and becomes deeper, the final shape has reduced the circle for a semi-elliptical

Figure 3 — Typical semi-elliptical head is shown just before removal from machine.

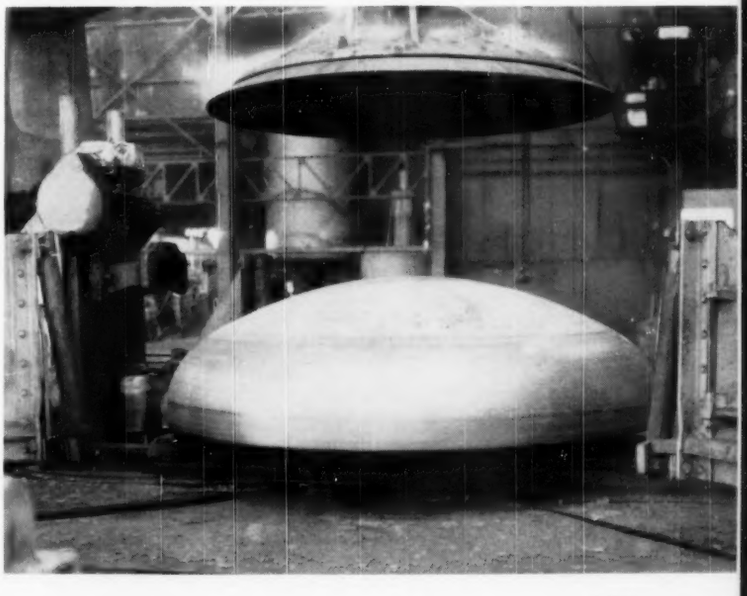


Figure 4 — Finished size is checked by a circumference wheel that measures travel on the flange.

Figure 5 — Conical and elliptical heads shown here have been formed from stainless steel.

head about 22 per cent, and for hemisphere about 35 per cent. A typical head of this type is shown in Figure 3.

A dual diameter gage with one scale for cold work and another with shrinkage allowance for hot work permits the operator to check head size during forming. Checking of finished size is by a circumference wheel that measures the travel on the flange. Figure 4 shows a closeup of checking for circumference. In the case of hot work, allowance is again being made for shrinkage with compensation for the wide range in finished temperatures resulting from different gages and variation in forming time.

Some type of heads require more steps than the semi-elliptical above discussed. For example, a hemispherical head would be started in the same manner, then worked down over elliptical dies and finally hemispherical; a 45-degree conical head would follow the procedure for hemispherical with conical dies for the final step.

We have spoken of steel. The process is equally applicable to stainless, nickel, copper, aluminum, and their different alloys as well as clad metals. Figure 5 shows shipment of stainless conical and elliptical heads. Some differences in handling are required to meet the differing forming characteristics of the metals. Heating temperatures run all the way from 1800 F for carbon steel to 2050 F for stainless, and down to 1400 F for copper and silicon bronze and 800 for aluminum. Shrinkage values are usually calculated in terms of relationship to carbon steel figures; stainless for instance being 1½ times and aluminum about two times that of carbon, and due allowance is made for the relative higher or lower forming temperature. Relative hardness is also a factor, thus in working aluminum wood rather than cast iron is used for the inner forming die on the first operation.

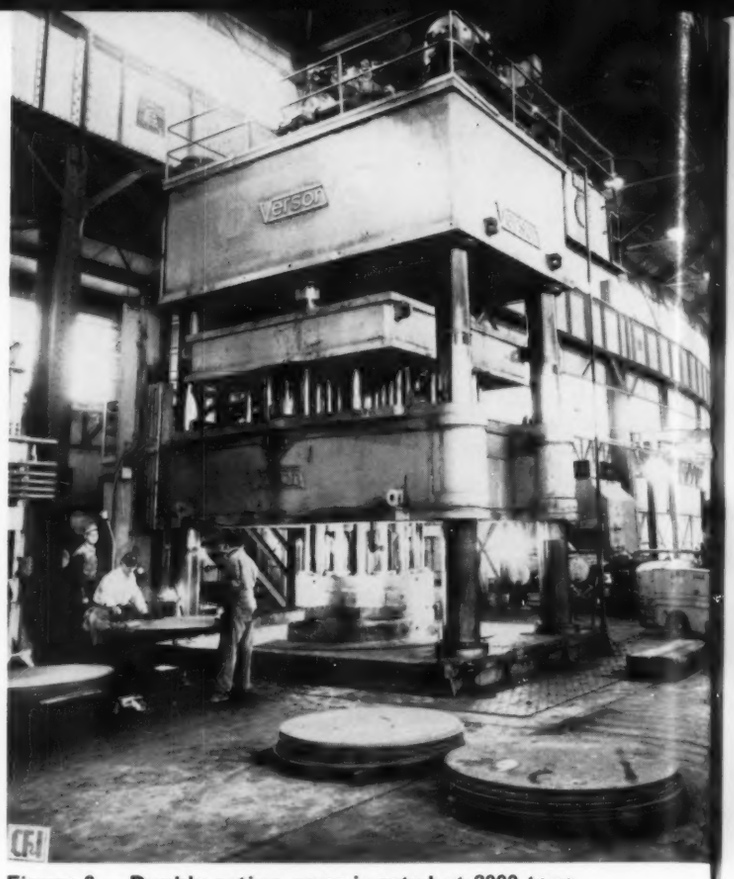


Figure 6 — Double acting press is rated at 3000 tons.

Requirement may exceed the width capacity of a plate mill in which event plates are welded together to obtain the circle blank of necessary size. We have found no difficulty with this, flush grinding being the only additional step; indeed, x-rays made before and after forming have shown improvement by elimination of small defects by the hot working of the metal.

Final inspection of surface, contour, circumference and roundness of all heads is standard. The heads are trimmed on machines developed for that purpose and gas or machine cut bevels for welding are made when specified.

Full facilities for special press work such as flued manholes or flue holes are provided. Annealing, sandblasting and pickling is standard procedure on all stainless material and other materials when specified. Special press work is performed in an open throat press of 333-ton capacity on the main ram with 84-in. clearance inside the ram and 84-in. throat depth.

We have recently installed two presses for production of flanged and dished heads by this more generally

known process. The smaller has 1600-ton capacity, 60-in. opening between posts and 86-in. daylight.

Because of its size and unique operating characteristics, there is much of interest, and also, of challenge in the large press.

It is big; being a double acting press with 2000-ton capacity on the main platen and 1000-ton on the clamp. It operates as a single acting press of 3000 tons. A view of this press is shown in Figure 6. Maximum diameter of head can be 126 in. with a capacity to produce by cold drawing a 60-in. diam head, ½ in. thick. The platen has a working area of 150 × 150 in. with 96-in. daylight and the main ram has a 72-in. stroke. Operationally, this press is designed so that the finished head leaves the die below the base of the press, whereas the conventional method would be to remove the finished head from the top with consequent delay. It is then lowered by elevator cylinder onto a conveyor and returned to floor level without interference with the next operating cycle.

Discussion

PRESENTED BY

H. E. BEEGLE, Technical Assistant, Flanging Dept., Lukens Steel Co., Coatesville, Pa.

H. S. BEERS, Superintendent, Flanging Dept., Wickwire Spencer Steel Div., The Colorado Fuel and Iron Corp., Claymont, Del.

E. C. PETERSON, Vice President in Charge of Engineering, Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa.

H. E. Beegle: As might be expected, the processes and equipment as described are similar to those in our plant, even though we do produce heads up to 23 ft in diam and 6½ in. in thickness.

Little mention has been made of the rather close tolerance on circumference or out-of-roundness that is commercially demanded on this product. Dimensional variations of plus or minus ½ in. on circumference are mandatory on heads of 96 in. diam, or a tolerance range of 0.3 per cent, so one can see that close control must be exercised.

The problem of tolerance ranges has been further accentuated by the close fit-ups that are required for modern welding procedures. Relative to tolerances, I would like to ask Mr. Beers how close he can hold outside and inside diameters on heavier gage heads—say above two in. in thickness. I would also like to know if he finds it difficult to maintain inside diameters on clad heads. This is extremely important on this class of product and it would be interesting to learn how he measures this dimension on hot heads.

Another important quality factor on flanged heads is surface contour and freedom from scale. Heads are often used in exposed positions where painting or enameling may high-light undesirable surface conditioning. I would like to ask Mr. Beers to describe his methods for minimizing scale, particularly on heads requiring long or repeated heating cycles which are most conducive to scale formation.

The hot spinning of the many grades of alloy material briefly described in the paper poses many additional problems for the producer. This is particularly true of stainless material where gages are usually rather light due to material cost. I would like Mr. Beers to give us some idea as to the number of heating operations on a light gage stainless steel head, the range of temperature allowed for heating (minimum as well as maximum), the subsequent heat-treatment to produce satisfactory metallurgical properties, and the attendant problems of head distortion and their correction.

Another source of difficulty in producing quality heads is the care and repair of forming equipment. Obviously, any roughness or mark on the formers will produce objectionable imperfections on the finished head. What particular system is used at Claymont to insure against such marking? The use of wooden rollers for forming aluminum heads was also mentioned. Are these rollers solid or of laminated construction? What type of wood is preferred and how long do these rollers last?

The manufacture of heads, regardless of shape or material, remains somewhat of an art combining the precision of a machinist in setting up the equipment and the artistry of a potter to translate power, motion and metal into the desired shape. We have here the art of the ancients bridging the centuries as we form the heads for the nuclear reactors of today's submarines and power plants.

H. S. Beers: First question is how close we can hold the outside and inside diameters on heavier gage heads of over 2 in. in thickness. I would say that the other dimensions of the head, particularly diameter, would determine whether or not we can resize cold. The 96 in. outside diameter head tolerance is plus or minus ½ in. on circumference. A 30 in. diam has a tolerance of plus or minus ⅜ in. However the cold size tolerance is plus or minus ⅛ in. on circumference for both sizes. The 2 in. thick 96 in. diam we can resize cold, but the 2 in. thick 30 in. diam we cannot resize cold and the only way to change it is to reform hot, and tolerance is then difficult to maintain.

As for maintaining inside diameter, the thickening and thinning of the metal make it practically impossible due to the fact that measurements during forming must be made on the outside. The only way accurate diameter can be maintained on inside is by machining. On clad material, which is usually lighter gage, the way we handle this material when inside circumference is to be maintained is to resize after annealing. The actual discrepancy on inside circumference is determined, this is then applied to outside circumference in the resizing after annealing. Even then maintaining inside circumference is difficult.

The next question is minimizing scale. We have purposely kept the furnace temperature down to 1800 F for regular operations, though sometimes it is necessary to go higher. This helps the scale condition, but naturally on heads such as hemispheres, which require a considerable number of hot operations, it is an impossibility to limit the scale, and therefore, the only thing that can be done is to remove it by another operation after forming.

Regarding the number of heating operations on light gage stainless steel, I would say that on most of our light gage stainless heads we find we make out better by doing most of forming cold, normalizing between operations. This would require five to six or more operations. After finished to size the head is normalized at 1950 to 2050 F and cooled to black within three minutes.

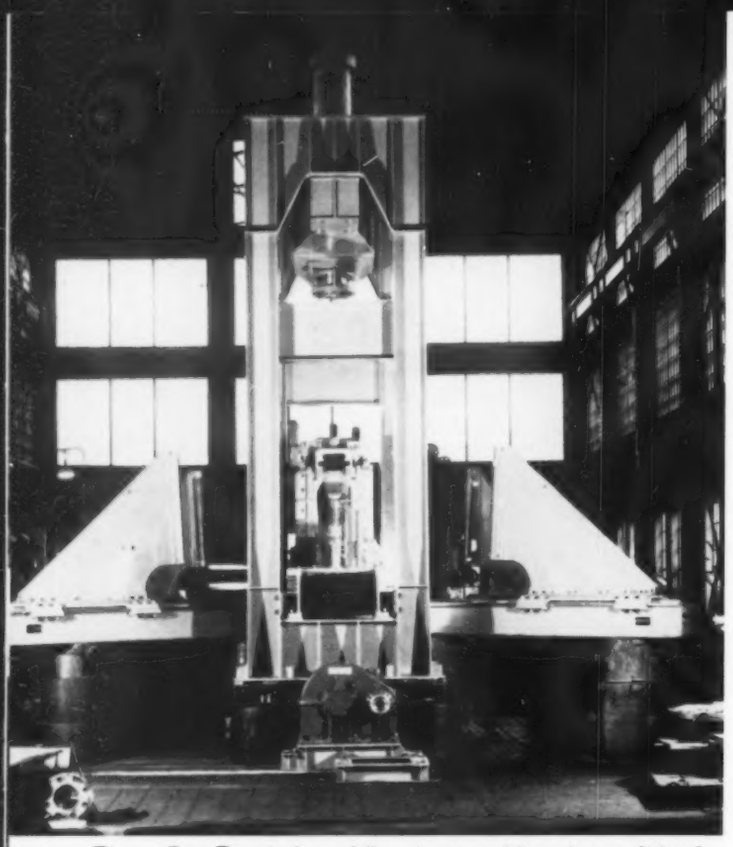


Figure 7 — Front view of flanging machine shows slides for centering roller and drive for main spindle.

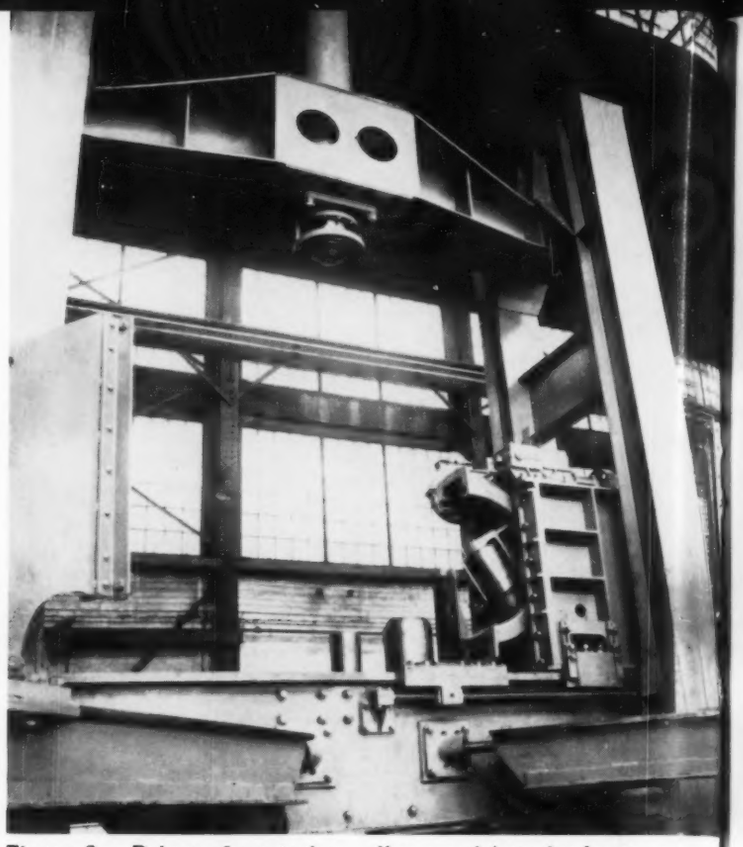


Figure 8 — Drives of centering roller are driven by large central gear.

Slight distortion from this high temperature can be taken care of by resizing cold.

There was a question of what system we use at Claymont to insure against marking from the roughness of dies. I would answer that the only thing to do is recondition the dies by grinding.

E. C. Peterson: Mr. Beers mentioned that his firm supplies a good part of the spun head market.

As far as we know there are only three firms in North America that are operating this type of machine. Since World War II the principal demand for machines has come from abroad. That may be because they have so many small markets over there, each protected by its own tariff walls, and therefore able to support its own spinning machines, while in this country a few machines can supply the whole demand.

At any rate, the machines have not changed basically in design over recent years.

Figure 7 is a machine at shop erection showing some of the mechanical features. This is an end view and also shows the slides for the centering roller and the drive for the main spindle.

Figure 8 is a side view of the machine. Here can be seen the drives for the centering rollers all driven by a large central gear. This picture gives a good view of the forming roll which slides around in the segment. The whole segment lifts up and down, and the entire mounting can traverse in and out, to give complete flexibility of positioning.

Figure 8 also shows the saddle roll which also can be traversed in and out by screws and, also the main spindle on which the bottom dies rest.

The principal changes have been more in matters of refinement than in change of basic design. One of the principal improvements has been that the machines now can be furnished with the top beam retractible, so that dies can be handled in and out of the machine by direct crane lift, rather than with a more cumbersome fork arrangement. And the main spindle can be also made to elevate and lower, which gives the user freedom in the design and use of dies. Also the saddle roll can be made to lift up and down, which modification Mr. Beers installed on his machine, although it was not originally made that way. This adjustment gives flexibility in the use of saddle rolls, and eliminates the necessity of lining up under them.

The spinning operation is one of the most difficult manually controlled machine operations that I have ever seen in the steel industry, and certainly requires a great deal of empirical skill on the part of the crew.

Mr. Beers mentioned that his company has recently installed some presses, and I would like to ask him to define a little more clearly what is the field for spinning as opposed to press work, and what the trend is at the present time, whether toward press working or spinning.

H. S. Beers: As regards to the two operations, pressing against spinning, I would say that the flexibility of the spinning operations is the big advantage. They both have a place where you have volume. If it can be pressed you can probably do it cheaper if quantities are sufficient to offset setup and die costs. But we find that there is still a big market for spun products. The bulk of our spun orders are around ten pieces or less, many for one or two pieces, which you can see is not much for a die change on a press which can run all the way from maybe an hour to three or four. This is not very economical, whereas with spinning we can readily handle orders of one or two pieces.

You can also combine a number of different diameters, for example, 119, 120 and 121 in. on the same setup of dies. Flexibility is the big thing on the spinning operation. ▲

Development and Application of Spray Lubrication

by E. J. GESDORF
Senior Application Engineer
The Farval Corp.
Cleveland, Ohio

Spray lubrication is probably the most practical and economical method of applying lubricant to open gearing, cables and chains . . . . experience and know-how play a vital part in the engineering of successful spray systems.

CENTRALIZED spray lubricating equipment was first introduced in the year 1950. At that time, our advertising department published a number of ads describing the equipment and announcing it as a new development for centralized lubrication. When the magazines carrying the advertisements reached the field, we were literally overwhelmed by an avalanche of response. People wrote in from all over this country and from foreign countries, wanting to know if we could spray glue, rubber cement, ink, cooking shortenings, roofing tar, rust preventives, asphalt tile emulsions, etc. Some of the inquiries asked if we could coat an area ¼ in. square without getting any of the spray onto the adjacent materials. Others wanted a ribbon spray that would lay down a 3-in. wide pattern with clearly defined edges. For every legitimate lubricant spray application inquiry we received, we received ten that were of a fantastic nature.

Out of the multitude of inquiries came one from a maintenance superintendent in a paper mill. This gentleman had a lubrication problem on a set of helical gears on the dryer roll section of a paper machine. Complete drawings were sent to us with the request that we design a spray system to serve this set of gearing. Our experience on paper mill gearing at this point was nil. We therefore suggested to our client that he purchase a hand-pump and spray control valve and nozzle, such as shown in Figure 1, for the purpose of trying out the idea before becoming involved in a large installation.

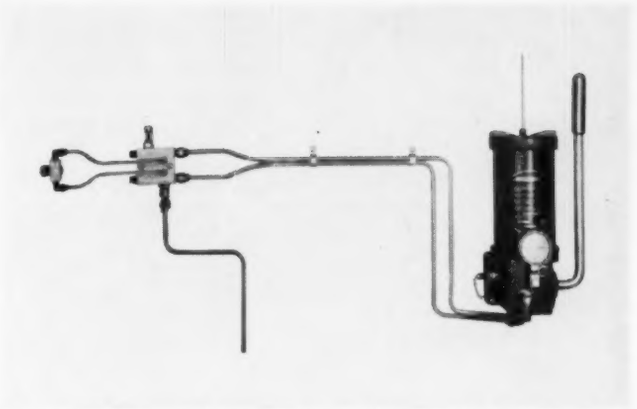


Figure 1 — One of the first installations consisted of a hand pump and spray control valve and nozzle.

This suggestion was followed and after a six-months trial period with the single nozzle manual installation, the customer was satisfied that the equipment would do the job. A complete automatic spray system, serving twenty 4-in. face gears, 55 in. in diam., was designed and installed in the year 1951. On the success of this installation and during the period between 1951 and 1956, this paper company was sold six additional automatic spray systems covering all the gearing on all of their paper machines. A typical spray system installation for the gearing of the dryer roll section of a paper machine is shown in Figure 2.

Experiences similar to the one described for the paper industry have been encountered in the cement and steel industries.

Another interesting application developed at a slag company in Alabama. A system was installed on a skip hoist to lubricate the plain bearings, drive gearing and cables. Spray was used on the gearing and cables. Conventional measuring valves were used for lubricating the plain bearings. This installation is illustrated in Figure 3.

There were two outstanding features on this job. One was the fact that the bearings, gears and cables were lubricated with one system and with one lubricant. The other feature was the ingenious nozzle arrangement used for spraying the cable. This is shown in Figure 4. The nozzle was mounted on a trolley which moved across the face of the drum as the cable was reeled in, or as the cable was paid out.

Before installing the automatic lubricating system, this company used a little better than 50 lb of grease every

week to lubricate the open gearing and wire rope. In addition, they used a light grease on the bearings, and frankly they do not know how much they used for this operation. However, they did use a hand-gun which required a considerable amount of labor, not to mention the risk of injury to the oiler.

Since installing the system, they lubricate the

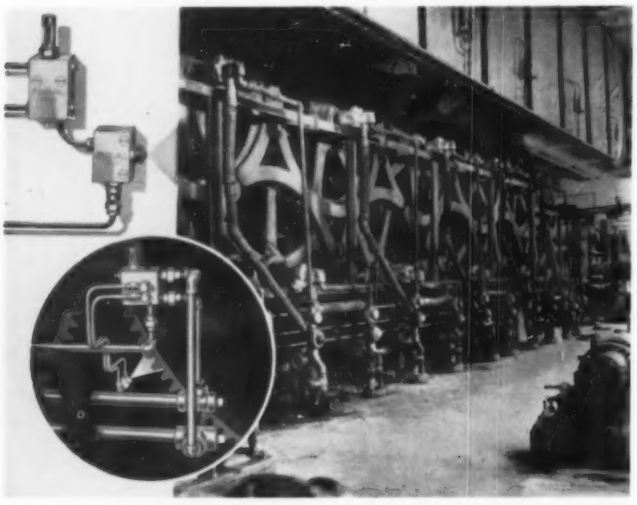


Figure 2 — Unit shown is typical spray system for paper mill dryer roll gearing.

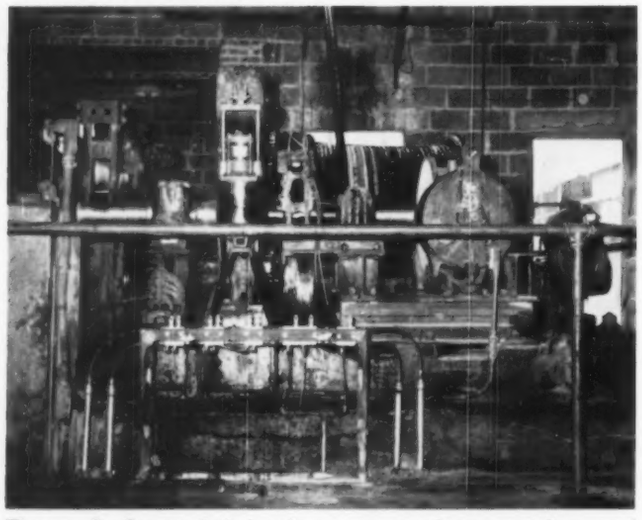
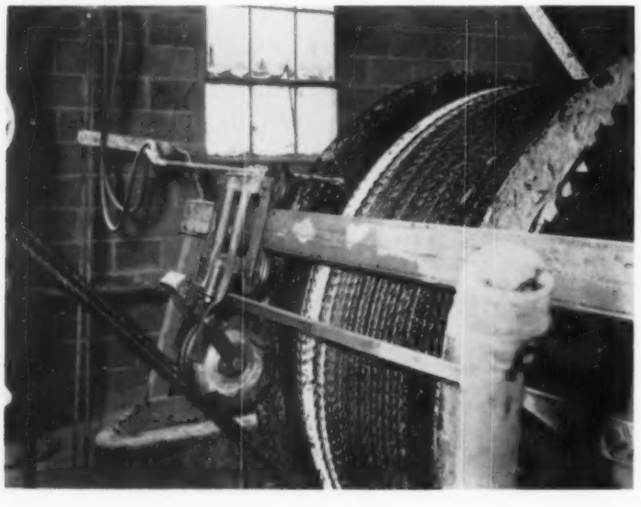


Figure 3—Spray lubrication was used on gearing and cables of skip hoist.

Figure 4 — An ingenious nozzle arrangement was used to spray cable.



open gearing, the wire rope and the bearings with but one type of lubricant, as mentioned in the foregoing. The system is operating on 30-min cycles, and under machine operating conditions similar to those they had before the lubricating system was installed, they estimate that a 400-lb drum of grease will last a little more than two years.

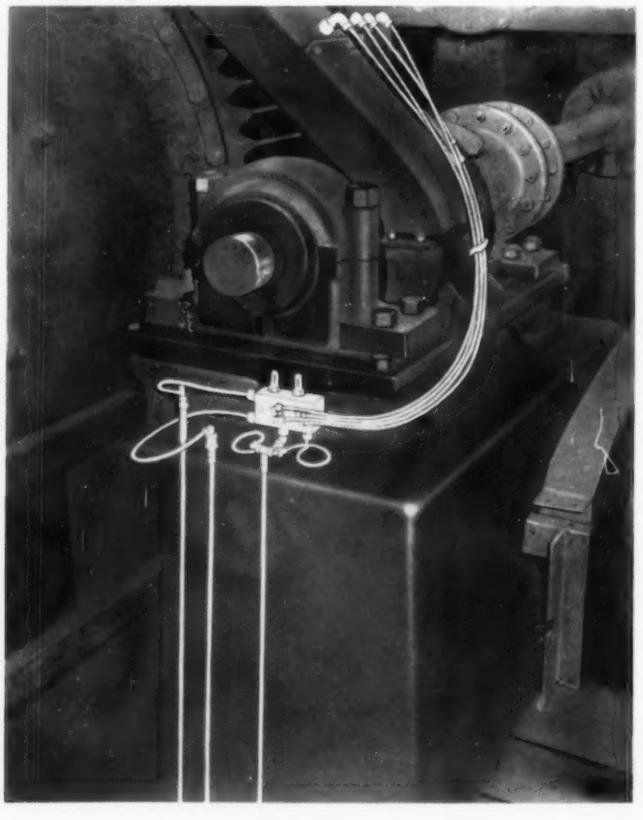
The savings and benefits brought about by the installation on the skip hoist led to additional spray system installations in the grinding department of this slag plant. Automatic spray systems were installed on ball mill gearing, as shown in Figure 5. One system was used to lubricate three mills.

Prior to the use of spray systems in the grinding department, drip and pour methods were used for lubricating the gearing, and it is estimated that five to eight gallons of lubricant were consumed during a 24-hr period.

With the use of the automatic spray system, lubricant consumption has been reduced to $4\frac{1}{2}$ quarts per 24 hr, which represents a substantial savings. In addition to the saving in lubricant, the lubricant as applied by the spray method is more efficient in that it gets the lubricant to the proper spots, which has resulted in marked reduction in pinion wear.

From these early beginnings, the centralized spray method of applying lubricant to open gearing has spread rapidly to presses, kilns, raw mills, finishing mills, rubber mills, paper mills and to numerous types of open gearing in the steel mills. It is true that open gears are gradually passing out of the industrial picture, although there are still thousands of open gear installations that will be in continued use for many years to come. Also, open gears are still being applied to new machinery being manufactured today where the cost of enclosing the gearing would be prohibitive.

Figure 5 — Automatic spray systems were installed on bar mill gearing.



THE MEASURED SPRAY MECHANISM

Before proceeding further, examine Figure 6 to better understand the mechanics of a centralized measured lubricant spray system. This illustration shows a typical centralized adjustable and indicating measuring valve with the discharge line connected to a spray control valve. When the system is operated, instead of the measured quantity of lubricant being discharged to a bearing, as it would be in a conventional lubrication system, it is fed to a spray control valve. The flow of lubricant moves a control piston to open an outlet port to the nozzle, and at the same time a check ball is unseated which permits a flow of air to the nozzle. The air and the gear lubricant are mixed just outside the nozzle tip to form a spray. After the measured quantity of lubricant passes through the nozzle, and is discharged in the form of a spray, the device automatically shuts off until the next lubricating cycle. The lubricating cycles can be controlled manually or automatically. With the adjustable cycling of the system and the adjustable metering valves, any desired quantity of lubricant can be sprayed onto a gear in a given period of time.

NOZZLE STUDY

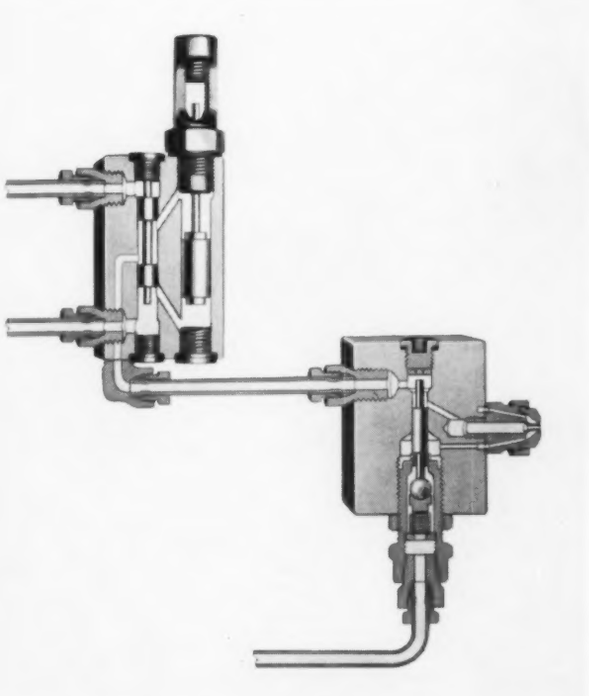
Pneumatic atomizing nozzles can be placed in two groups; one, the internal atomizing type; the other, the external atomizing type. Further classification can be set up in accordance with the type of spray whether it be round, wide angle round, or flat. However, investigations have indicated that for the general spraying of open gear lubricants of the residual type, nozzles designed for external atomization and producing a round spray are best suited.

Figure 7 shows a sectional assembly view of a typical internal mixing nozzle. Internal mixing means that the lubricant and air are brought together inside the nozzle tip where atomization takes place. The objection to this type of nozzle design for application of lubricants, particularly where solvent cutback lubricants are used, is that there is constant danger of plugging the discharge orifice should the lubricant dry out or harden between spray cycles. If this occurs, subsequent shots of lubricant flow into the air line instead of being discharged in the form of a spray.

Flat spray patterns can only be produced with internal atomization nozzles. Unless the lubricant used is of the nondrying and nonhardening type, flat spray nozzles are to be avoided because of the hazards pointed out for internal atomization nozzles. Incidentally, the pattern resulting from a flat spray is elliptical in shape.

A sectional assembly view of an external mixing nozzle is shown in Figure 8. External mixing means, as the name implies, that the lubricant and air are brought together outside the nozzle tip where atomization takes place. The lubricant is discharged through the center orifice to the atmosphere. The high velocity stream of expanding air that surrounds the fluid orifice picks up the lubricant as it is discharged, atomizing it to form the spray. The chief advantage of this type nozzle de-

Figure 6 — In measured spray unit, measured quantity of lubricant is fed to a spray control valve.



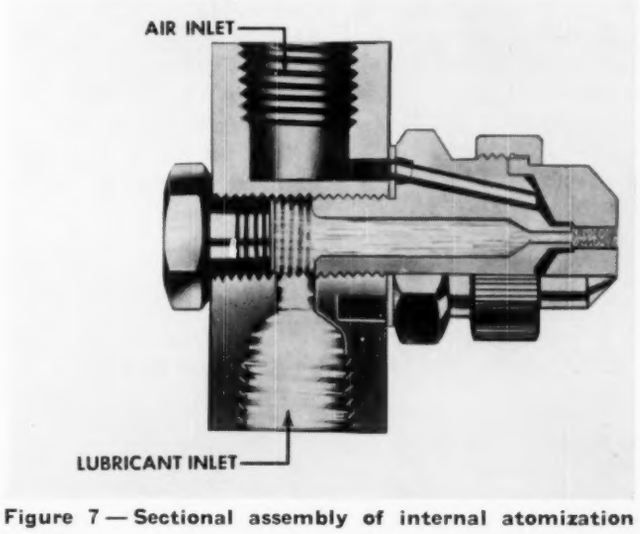
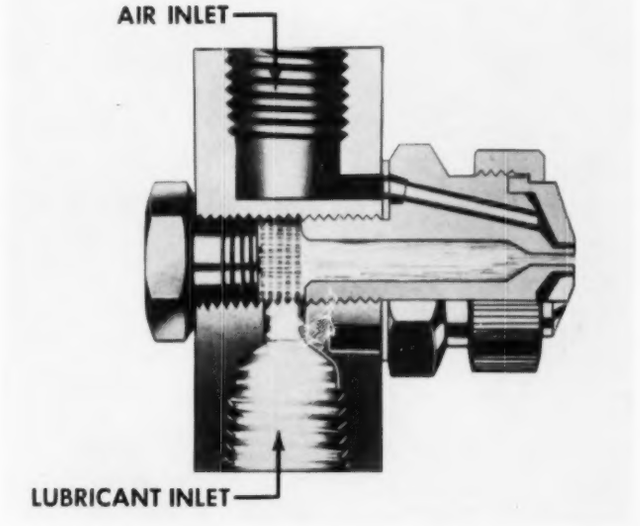


Figure 7 — Sectional assembly of internal atomization nozzle.

Figure 8 — Sectional assembly of external atomization nozzle.



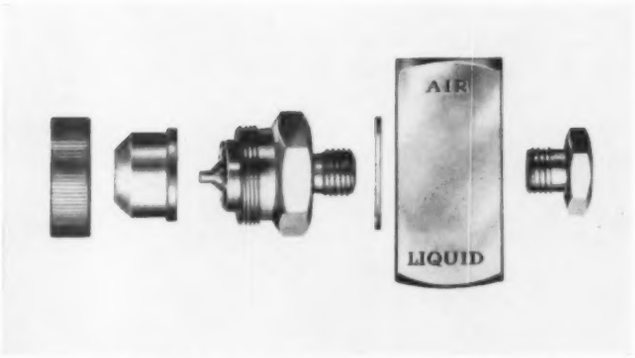


Figure 9 — Main components of nozzle assembly.

sign is that it is not susceptible to plugging as the full pressure of the lubricating system is effective in flushing the fluid orifice during each lubricating cycle.

The main components of a nozzle assembly are shown in Figure 9. For our purposes, we have dispensed with the nozzle body and are using just the air and fluid nozzle assembly. This assembly is screwed into the spray control body. A large assortment of interchangeable air nozzles and fluid nozzles are available, each varying in orifice diameter. All air nozzles and fluid nozzles of the type we use are stamped with numbers giving the orifice diameter. On an air nozzle, the No. 64, 120, or 200, for example, would mean the air orifice is 0.064, 0.120, or 0.200 in. in diam. Fluid nozzles would be stamped with numbers such as 60100, 2050, 100150, which gives the I.D. and O.D. of the fluid tip. A 60–100 fluid tip means that the I.D. of the orifice is 0.060 in., while the O.D. is 0.100 in., etc.

NOZZLE ARRANGEMENT WITH RESPECT TO THE GEAR

A considerable amount of thought has been given to nozzle spacing and angle of spray with respect to obtaining the most efficient coverage of the gear. Data developed for us by a leading gear manufacturer and a leading mill manufacturer provided us with information on the required nozzle spacing based on a nozzle to gear distance of 6 to 8 in. and an angle of spray of 30 degrees. These specifications are applied constantly by our engineers for spray system planning.

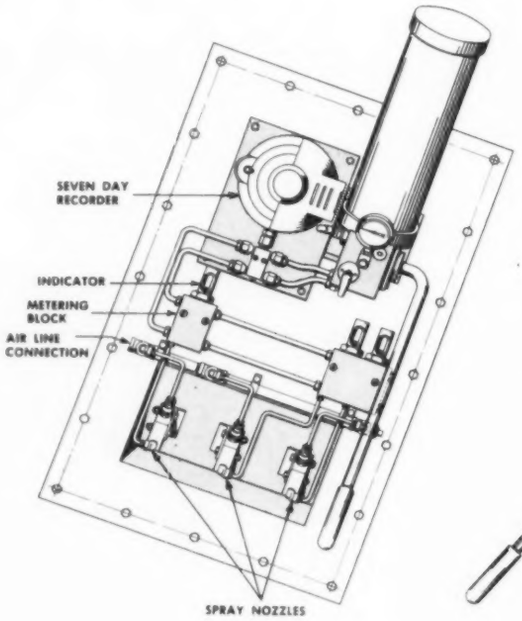
Figure 10 shows a self-contained manually operated spray panel which was designed for gear guard mounting. This illustration gives the nozzle to gear distance and angle of spray dimensions. Figure 11 shows a manually operated spray system mounted on a ball mill gear guard. The chief objective in nozzle location is to direct the lubricant spray to the pressure side of the gear teeth and to obtain good coverage of the gear face. Manual spray systems are used where one coating of lubricant on the gear will last for several hours and where the attendant can be depended upon to operate the system.

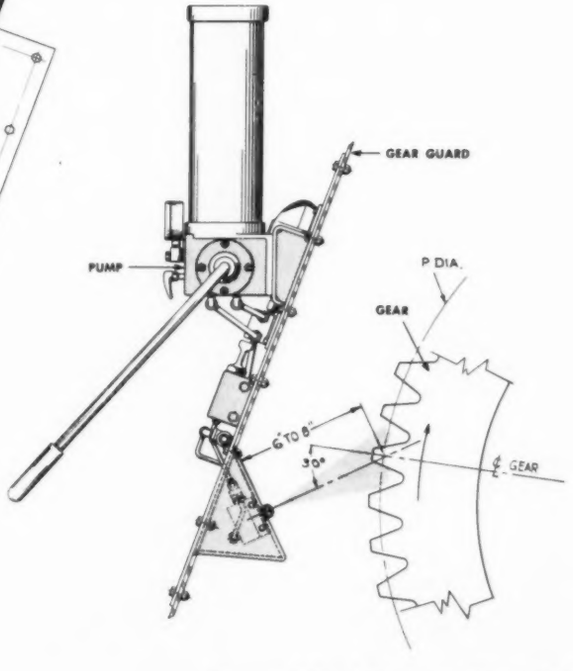
A majority of people on first thought feel that the ideal spot for spraying lubricant on a gear and pinion is at the point of mesh. Experience has taught us differently. On a great many gear and pinion sets the air turbulence at the point of mesh, resulting from air ejection of the meshing teeth, is such that lubricant spray cannot satisfactorily penetrate the back currents.

Figures 12 and 13 represent standard practice for nozzle location on two specific applications. The principles illustrated can be applied to other types of gear installations. Figure 12 shows an automatic spray panel installation on a ball mill. The average gear speed for this type of installation is approximately 18 rpm. The location of the nozzles gives easy spray access to the pressure side of the gear teeth. The gear is turning at a speed sufficient to insure good distribution and coverage during a relatively short spray period.

Figure 13 shows an automatic spray panel installation on a kiln. The average gear speed for this type of

Figure 10 — Manual gear lubrication system can by addition of a timer, reversing valve and motor driven pump be converted to automatic operation. Panel shown is typical for gears of about 20-in. face width. Wider gears will require four nozzles, narrower gears one or two nozzles.





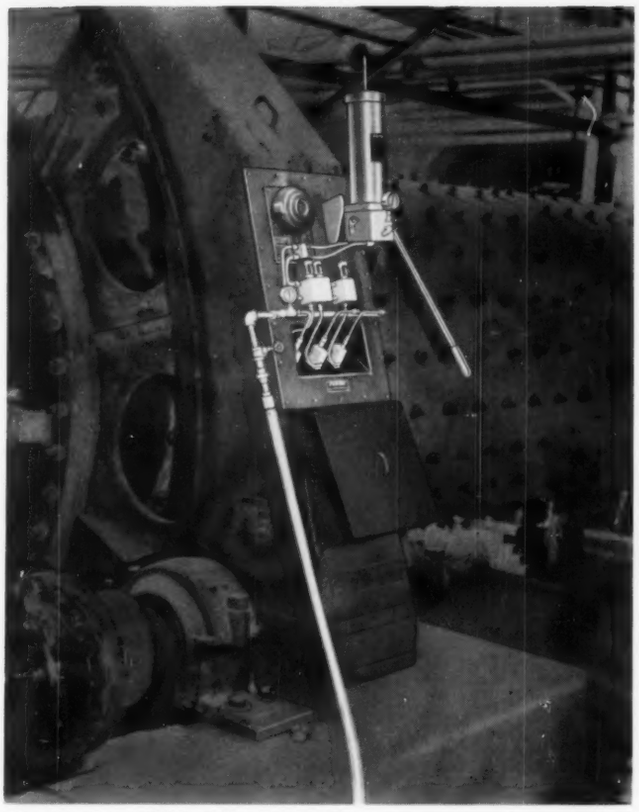


Figure 11 — Manually operated spray system is mounted on a ball mill gear guard.

installation is approximately 1½ rpm. Note that in this case the pressure side of the pinion teeth are being sprayed. Spraying a large gear traveling at 1½ rpm by the intermittent method would not be a practical application method because poor distribution of the lubricant will result. Figure 14 shows all of the equipment included in an automatic spray system for single gear and pinion applications.

It is our opinion that an inspection door should be installed on all gear guards at right angles to the gear face and adjacent to the location of the spray nozzles, as shown in Figure 15. The spray pattern can then be conveniently checked at periodic intervals by inserting a cardboard through the inspection door.

EVALUATION OF SPRAY PATTERN

During our early experience with spray equipment we were assigned the task of evaluating spray patterns. In studying the problem, it was found that there are six prominent variables which affect lubricant spray pattern and these are listed as follows:

1. Type of lubricant.
2. Type of nozzle.
3. Nozzle to target distance.
4. Air pressure.
5. Room temperature.
6. Lubricant temperature.

It is recognized that there are other variables; however, in comparison with the variables listed they are of a minor nature in importance.

The next obstacle to overcome was that of recording the data taken during the investigations in such a way that it could be studied and verified by others. If you do not agree that this was a real problem just try to give a word description of 12 different spray patterns that can be clearly understood by anyone other than yourself. Actually, with the number of variables present, an infinite number of spray patterns are possible.

Figure 12 — Cutaway view shows automatic spray installation on ball mill.

Figure 13 — Cutaway view shows automatic spray installation on kiln.

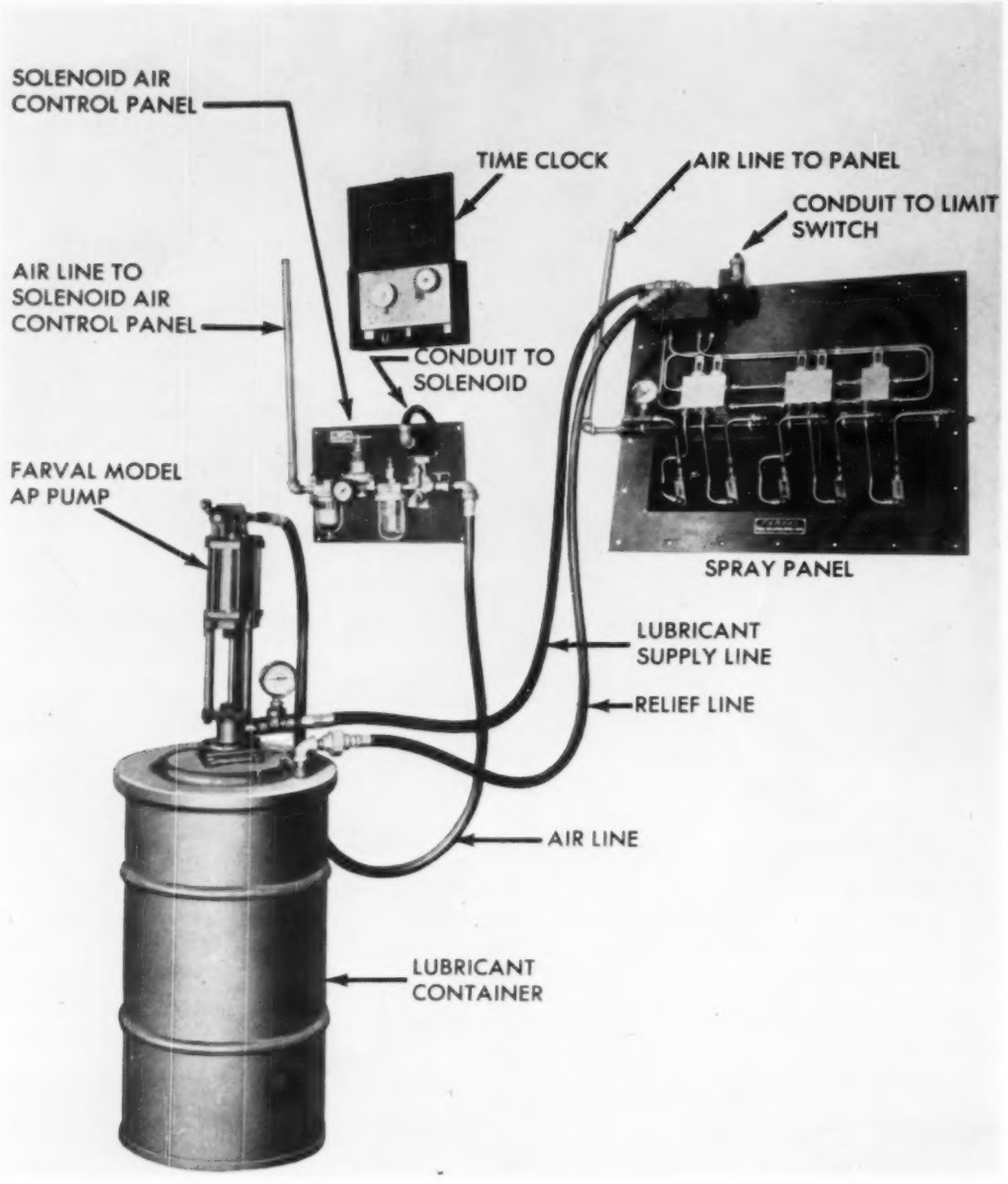


Figure 14 — Typical automatic spray system layout.

After considerable thought, a recording method was worked out which gave a permanent record of our experiments with a complete description of the resulting spray pattern that could be understood by anyone. Furthermore, easy duplication of the results were made possible for consultation with engineers in remote areas.

An illustration of the method used in recording spray pattern investigations is shown in Figure 16. Here you see the possible variations in spray patterns with one lubricant. Four of the variables were held constant while the air pressure and the distance from the nozzle to the target were varied. Figure 17 shows four spray patterns made with the same lubricant again but with the temperature of the lubricant elevated approximately 8 F over the previous test. The four spray patterns shown in Figure 18 were also made with the same lubricant but this time different spray nozzle tips were employed. It can be seen from these illustrations the vast assortment of spray patterns available.

From these investigations a set of standard characteristics have been developed for spray systems which will produce the greatest flexibility in the equipment to handle the broadest range of conditions encountered in the field.

TYPES OF LUBRICANT SPRAYED

One of the most frequent questions asked in connection with spray lubricating systems is "Can your system spray material XYZ?" We might say at this time that the limiting factor of a spray lubricating system is pumpability of the lubricant. If the lubricant cannot be pumped it cannot be handled in a centralized metered spray system. The limiting factors in a spray lubricating system are the same as those in a conventional centralized lubricating system. This does not give anyone a great deal to go on. However, in the absence of a true indicator of lubricant pumpability at present, we have data sheets giving a long list of open gear lubricants along with typical specifications of the lubricants that are being successfully sprayed through the kind of equipment we are discussing. This information is being used constantly by our engineers for spray system planning. Many of these lubricants cannot be handled under all temperature conditions in the field. Some of

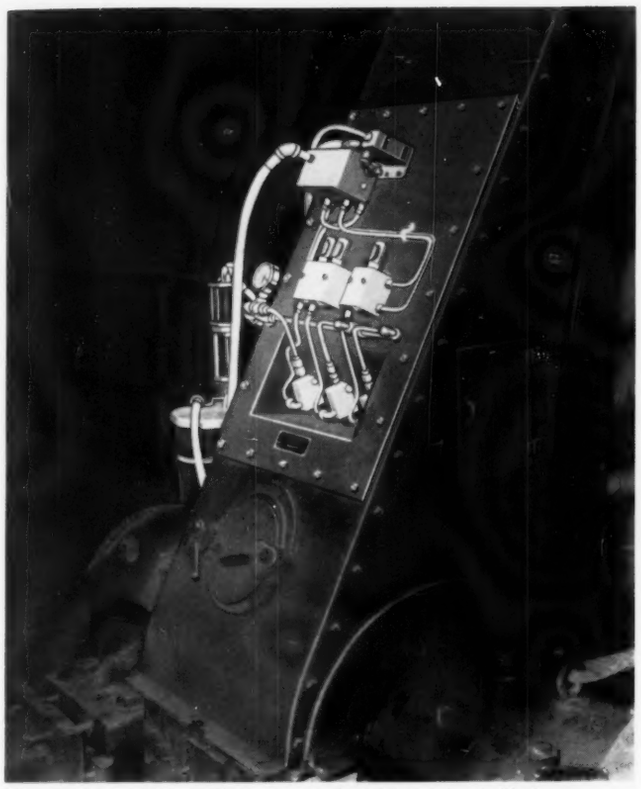
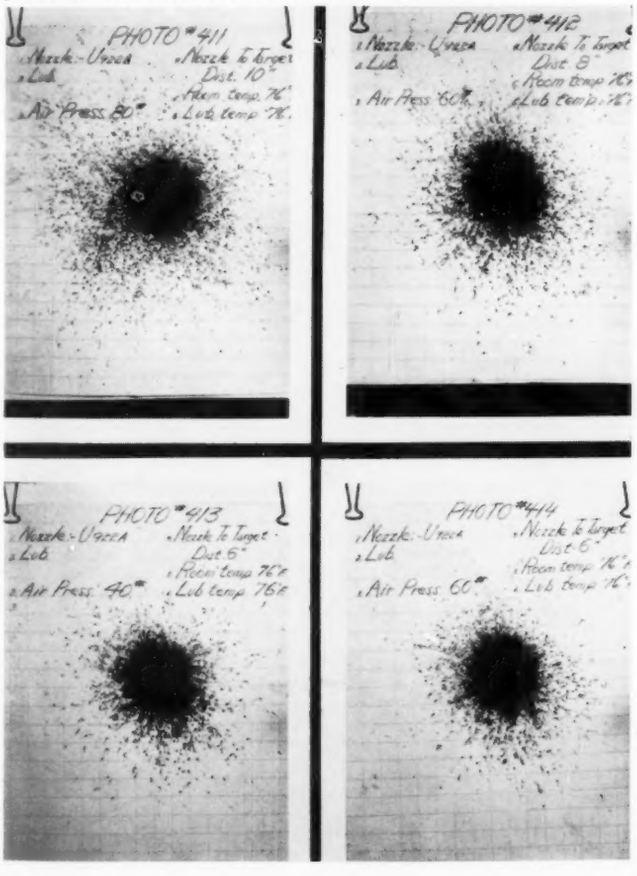


Figure 15 — Inspection door should be installed on gear guards at right angles to gear face.

the lubricants can only be handled at elevated temperatures. Fortunately, there are a number of good open gear lubricants that can be pumped at low temperatures without heating.

Figure 16 — Variations in spray pattern are shown with air pressure and distance from nozzle variable.



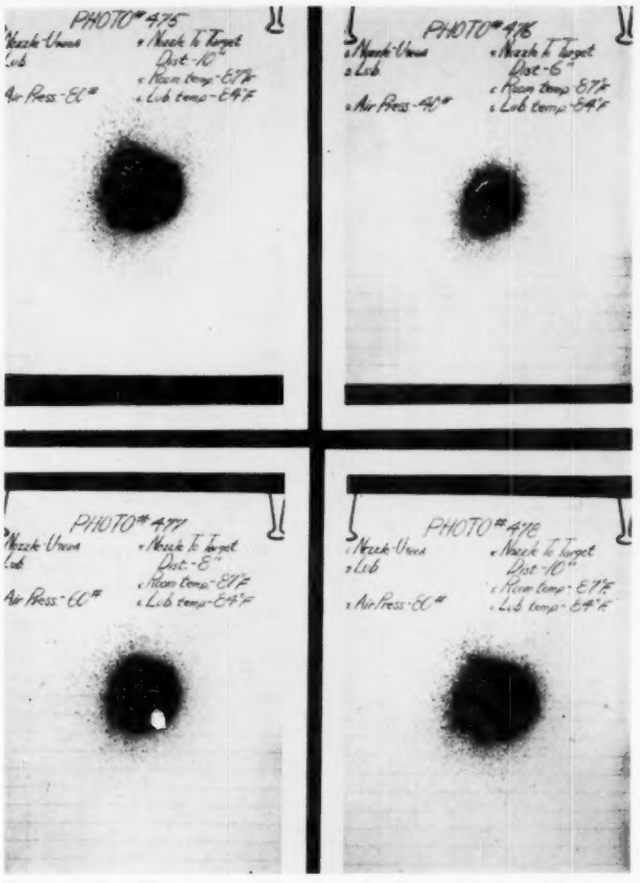
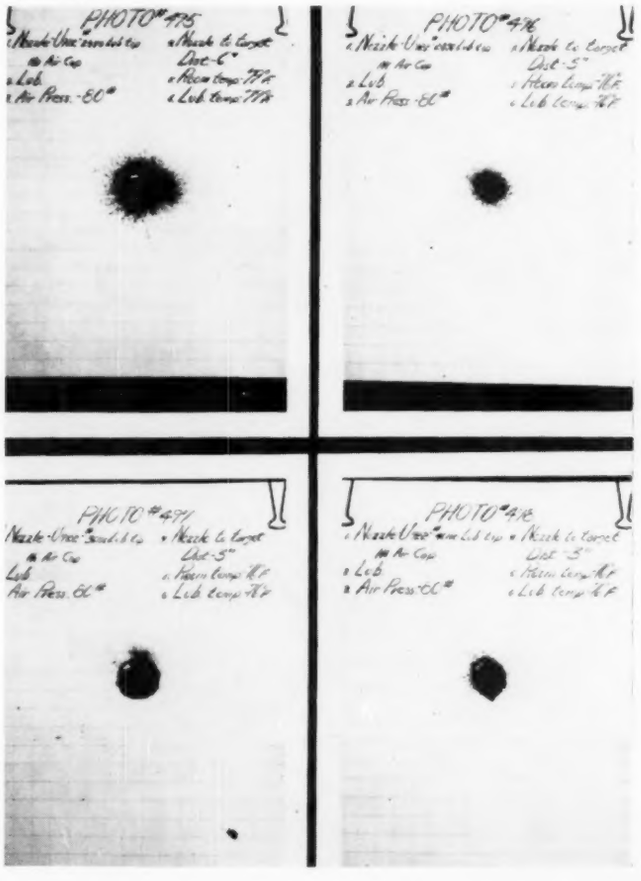


Figure 17 — These four spray patterns were made under the same conditions as those in Figure 16 except temperature was raised eight degrees.

Figure 18 — Different spray nozzle tips gave different spray patterns.



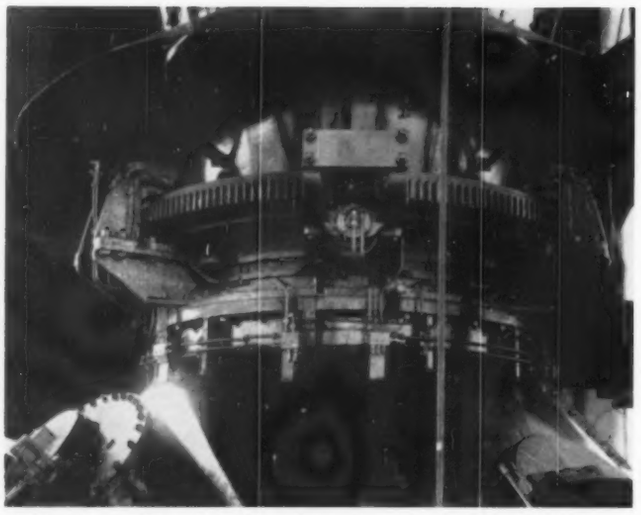


Figure 19 — The addition of a measuring valve and a spray control valve to the blast furnace eliminated hand swabbing of the ring gear.

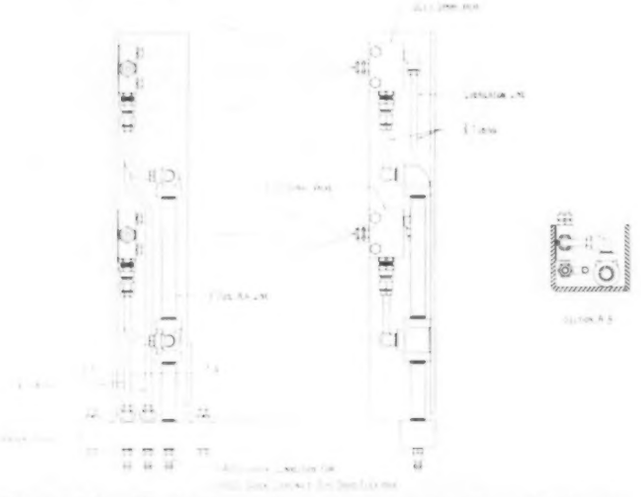
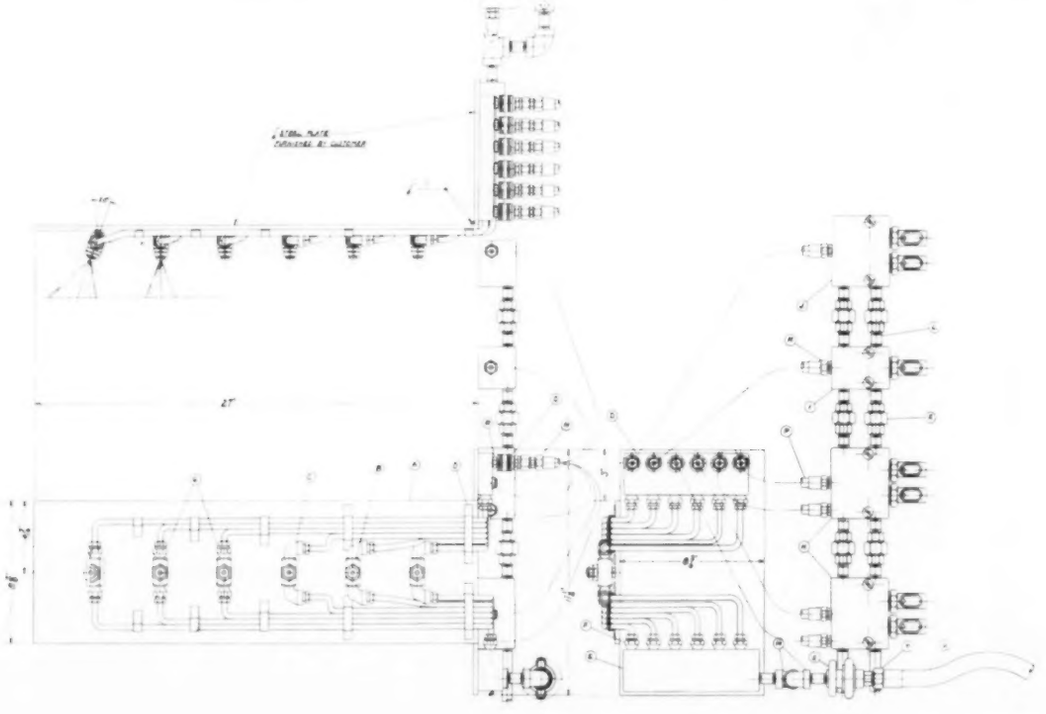


Figure 20 — Typical nozzle bracket can be slipped between roll neck and mill housing for roll neck spray lubrication.

Figure 21 — Plan view of spray nozzle bracket.



STEEL MILL SPRAY SYSTEM APPLICATION

Lubricating the ring gear on a blast furnace distributor, such as shown in Figure 19, has always been a disagreeable job. At one of the eastern steel mills, the daily job of hand swabbing the 5-in. face, 12-ft diam ring gears on eight blast furnaces was eliminated by adding one measuring valve and one spray control valve to the existing automatic lubricating system on each furnace. Good gear lubrication is now being provided automatically and safely, at two-hour intervals, with complete elimination of the labor that was formerly required. Figure 19 does not show the spray equipment serving the gears as the photograph was taken before the spray valve and nozzle were added.

Lubrication of the rack and pinion gears on a hot strip mill furnace pusher at a southern Ohio steel plant is another lubrication problem that was solved by adding a measuring valve and spray control valve to an existing system.

Where there has been sufficient clearance between the roll necks and the mill housings on some of the older blooming mills, centralized spray lubricating systems have been installed with success to lubricate the roll neck bearings. The roll necks of these mills are usually sprayed during the winter months with extreme pressure gear oils having a viscosity of 250 SSU at 210 F. During the summer months, extreme pressure gear oils with a viscosity of 500 SSU at 210 F are used. Figures 20 and 21 show typical spray nozzle brackets that can be slipped between the roll neck and mill housing for roll neck spray lubrication. Quick coupling air and lubricant lines are used to connect the nozzles after they are in place. One mill reports the following savings as a result of roll neck spray lubrication:

1. Effective bearing area increased and machine shop time on bearings decreased since there is no drilling, tapping or grooving required.
2. Considerable increase in bearing life.
3. Elimination of roll neck dressing as necks show

Figure 22 — Metering valves were installed outside gear housing.

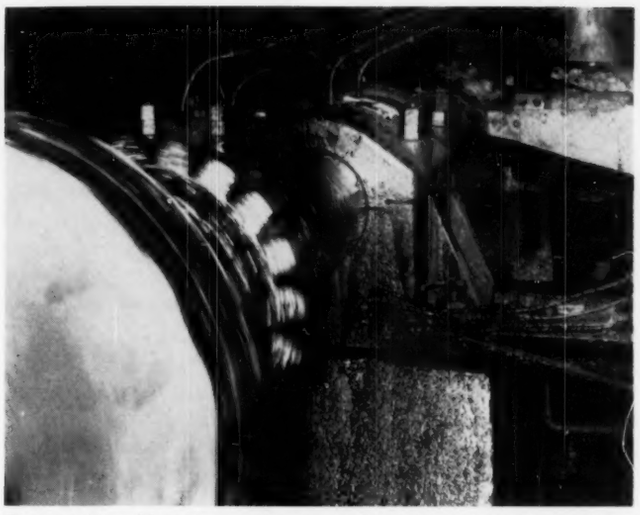


Figure 23 — Metering valves were installed close to gearing.

no signs of wear, heating, scoring or cracking and the fillet maintains good condition.

4. Fifty per cent less lubricant consumption.

A spray system was installed on a line of bevel gears on an old mill table where it was common practice to replace the line shaft and bevel gears every two weeks. The last time this job was checked, it was learned that the spray lubricated line of bevel gears had been in service several months with no signs of needing replacement.

A mill in Texas reports that an automatic lubricating system was installed on a set of mill tilting tables to lubricate the table roll bearings, line shaft bearings and bevel gears. These tables are lubricated every three minutes with an extreme pressure leaded oil having a viscosity of 1500 SSU at 100 F. The savings in bearings and gears alone resulting from the installation of the lubricating system amounted to approximately $15,000.00 per year. We all know that this mill must also have benefited from less downtime as with fewer gear and bearing replacements it is only natural that there would be less loss of production.

In 1954, a 14-point automatic spray system was installed on the drive gearing of a 19-in. bar mill in a steel plant in Indiana. The metering valves were installed outside the gear housing as shown in Figure 22. The spray control valves and nozzles were installed close to the gearing as shown in Figure 23. Figure 24 will give some idea of the size of the gearing. These gears are now spray lubricated on 30-min cycles and the lubricant used is a residual type lubricant having a viscosity of 900 SSU at 210 F after evaporation of the diluent. This installation paid for itself in less than one year.

Prior to the installation of the spray system, 25 drums of lubricant were used annually to lubricate the gearing. Drip and pour methods of application were used. Once each year the gear pits had to be cleaned at a cost of $535.00 in labor. This labor cost figure was taken from a 1950 record. Under present day wage scales the clean-up labor cost would be much greater.

The spray system is now lubricating the drive gearing with but four drums of lubricant per year—a saving of 21 drums of lubricant. Furthermore, the gear pits have not been cleaned since the system was installed in 1954.

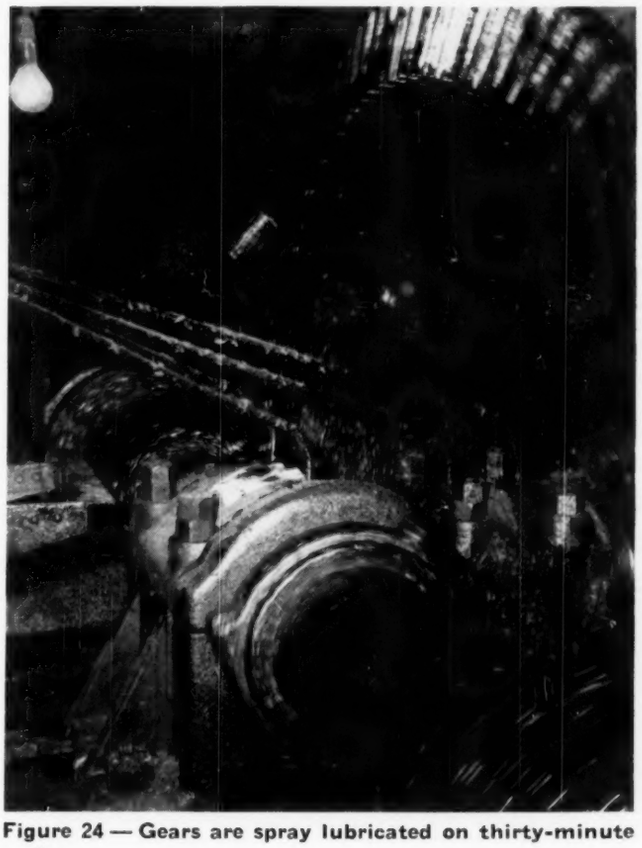


Figure 24 — Gears are spray lubricated on thirty-minute cycles.

This has resulted in an additional annual labor saving of more than $535.00.

To verify the story on the bar mill drive, two similar installations were checked—one in the Chicago district and one in the Pittsburgh district. The report on the Chicago installation indicates that lubricant consumption was reduced from one drum per week to two drums per year—a yearly saving of 50 drums of lubricant. A comparable story was given on clean-up labor savings.

The report on the Pittsburgh installation covers a spray system on a 21-in. billet mill which includes 21 large gears varying in diameter from 12 to 5 ft. The records were checked for eight years, four years before the system was installed and four years after the system was installed. In addition to substantial savings in lubricant and clean-up labor, gear replacements were

reduced 65 per cent and heat-cracked gears were completely eliminated.

SUMMARY

The following summarizes the main points covered in the discussion.

1. The early history of centralized spray lubricating systems was traced to illustrate how the initial successful spray installations led to widespread use of the equipment in all types of industry.
2. The measured spray mechanism was explained to give knowledge of how the device operates.
3. Different types of nozzles were explained, giving advantages and disadvantages of various nozzle designs.
4. The theory of nozzle spacing and arrangement with respect to the gear was explained.
5. Evaluation of spray patterns was discussed.
6. General information on the types of lubricant that can be handled in centralized spray lubricating systems was given for guidance in selection of proper lubricants.
7. Steel mill spray system applications were discussed to give some knowledge of the savings and benefits brought about by the use of this equipment.

Lubrication of open gearing by the spray method is being accepted as the most practical and economical method of application conceived to date. However, since spray lubrication of open gears, chains and cables is not an exact science, it is important to remember that experience and know-how play an important part in the engineering of successful spray system installations.

Discussion

PRESENTED BY

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ARTHUR SUTPHIN, General Foreman, Mechanical Dept., Great Lakes Steel Corp., Ecorse, Mich.

C. B. Kimpel: The spray application of lubricants has been, in my opinion, one of the most outstanding recent developments in lubrication. I would supplement Mr. Gesdorf's paper by briefly describing roll neck and open gear applications of series manifold type spray systems currently in operation at the Duquesne Works of the United States Steel Corp.

Our first installation was made on the necks of our 40-in. blooming mill where spray application of tacky, asphaltic residual extreme pressure oil replaced the old method of hand packing the necks with block grease. Our primary reason for making this change was to attempt to increase bearing life to the point that roll changes would be dictated by the condition of the work surface of the roll instead of the condition of the bearings. We easily accomplished this, but in addition found that we had also:

1. Improved safety conditions by eliminating the need of having the crew hand-pack the necks.
2. Reduced mill downtime by doing away with hand-packing.
3. Reduced bearing costs by eliminating bronze inserts in tin-base babbitt bearings and using lead-base babbitt bearings.
4. Effected a slight reduction in the lubricant costs on these necks.

On our series manifold type system we continuously apply oil to the four 22 x 22-in. necks at the rate of four cu in. per min with 0.5 of the oil applied to the bottom necks, 0.4 to the top necks and 0.1 to the mill windows. The amount of oil delivered to the system is controlled at the electric-driven positive displacement barrel pump and the series feeders merely proportion this quantity. When we first placed this system in service, we pumped at the rate of 11 cu in. per min with the system in operation on a cycle of two minutes "on" and two minutes "off." With this intermittent application we found that in the "on" period we were over-lubricating the bearings, and that toward the end of the "off" period, due to the continuous washing action of the water on the necks, we were running on boundary lubrication. Continuous application at four cu in. per min provided adequate lubrication 100 per cent of the time and also reduced lubricant consumption by 27 per cent.

Another advantage in continuous application at low pumping rates is that very viscous material can be pumped through the winter months without encountering high system pressures. In our case, for a great part of last winter, we pumped 750 SSU at 210 F asphaltic residual extreme pressure oil a distance of approximately 40 ft with the pump pressure not exceeding 1000 psi even on start-up. During summer months the pump pressure does not exceed 200 psi.

An indication of the savings possible on spray lubrication can be obtained from our experience on our 29-in. 3-high rougher. With block grease on these necks a set of bearings rolled an average of 43,000 tons. Our last set of spray lubricated bearings rolled 77,000 tons and still showed essentially no wear. Here again, roll changes are now dictated by the condition of the rolls, not by the necks or bearings.

Our second type of system at Duquesne Works is installed on the drive of our 14-in. continuous 8-stand billet mill. This system spray applies 750-sec extreme pressure oil to open bevel drive gears and the same lubricant, under pressure, to babbitted main drive sleeve bearings. This system is controlled by a timer, with the pump in operation two minutes out of every half-hour. Air to the spray is controlled by a solenoid valve which cuts off through a time delay relay, which is set for 30 to 45 sec, to provide spray air to atomize the oil which discharges from the system after the pump shuts down. This greatly improves housekeeping, for it eliminates the build-up of lubricant under the spray nozzle that will develop if this final flow, which results from the ex-

pansion of the lubricant in the line, is not atomized.

Here our primary reason for installing the system was to eliminate the danger to the oiler who had to hand-lubricate the gears and bearings on this drive with the mill in operation. However, here again we have found that worthwhile savings have resulted from:

1. Reduction in repair and maintenance expense.
2. Reduction in lubricant consumption.

Wayne G. Ritter: Proper grease lubrication comprises the replenishment of the very thin film of lubricant on the bearing surfaces as this film is wiped off. Any grease added which is in excess of the amount required for this thin film is wasted lubricant. The art of automatic lubrication practice therefore consists in the judgment as to the proper time interval to apply the lubricant and the amount to apply.

On roll neck bearings on the older mills, it is possible, to achieve almost this ideal lubrication practice through the use of spray lubrication. If we apply the lubricant at a constant very low rate, in minute particles over the full face of the neck and thrust surfaces, with a good extreme pressure lubricant, with provision for keeping out scale and foreign materials, very amazing results can and have been achieved.

We disagree with the author that internal atomizing nozzles should not be used. Since a flat pattern can be achieved by use of the flat atomizing nozzle it is useful in spreading out the lubricant and more important yet, such internal atomizing breaks up the lubricant into smaller particles which utilizes the lubricant more economically. We have used the flat spray and find it very useful. It is necessary of course to modify the commercial pneumatic atomizing nozzle shown in Figure 7 of the author's paper. This modification is simple and reduces the possibility of the grease clogging up the orifices. True, the flat spray pattern is slightly elliptical in shape but it still spreads out the lubricant and does not give the big globs of lubricant the round pattern gives, as shown in Figures 16, 17 and 18 of the author's paper.

We have often found it preferable to eliminate the valve as shown in Figure 6. We have found it useful to bring on the air with a solenoid valve at the same time as the automatic pump is energized. In addition we leave the air on after the grease pump shuts off long enough to purge all of the nozzles. Of course, on manual systems as shown in Figure 10, the grease valve is very useful but may waste air if it does not completely close, which is a condition very often found with anyone's valve which utilizes a piston, ball check and spring in the presence of cut back solvent type lubricants.

J. R. Sadowski: Closed lubrication systems have been used successfully for many years but open gears and exposed journals were usually neglected. Spray lubrication, developed fairly recently, closed the gap between partial and complete centralized lubrication of practically any present day equipment. The author has covered the subject very well and I do not intend to belabor any of the phases covered, except to point out that full advantage should be taken of all potential existing in these systems. Making use of the engineering know-how and experience of the technical and field experts provided by the lubrication equipment manufacturer can accomplish this end. This engineering service will pay dividends through proper installation; and maximum benefit of the cooling effect of the air-lubricant spray will be obtained particularly where difficult or critical lubrication situations exist.

At least two useful by-products are obtained through the installation of spray or "open" lubrication systems. These are: first, the added safety features mentioned are extended further than to the oiler alone. Other maintenance, and operating personnel as well, will be exposed to less hazardous conditions by eliminating or greatly reducing slippery conditions caused by injudicious application of lubricants. Secondly, since the lubricant can actually be seen in action, the education of maintenance personnel in the optimum amount of lubricant used and the frequency required for proper lubrication of other equipment he may service manually, can be more readily achieved. A word of caution here is advisable as employment of the same frequency of lubrication to an enclosed lubrication point can obviously lead to over-lubrication. However, the value of this "yard-stick" for maintenance personnel cannot be over-emphasized.

If your particular organizational structure is such that you perform strictly a service function and must "sell" centralized lubrication to management, then you can recruit the safety engineer and maintenance engineer as your aides; and the points discussed above may be the ones to put you "over the hump," so to speak, in your recruiting program and final "sale." The recruiting should not stop there, but should be extended to include cost accounting through the savings potential indicated through longer equipment life and lower depreciation costs. Heads of operating departments have alert ears for anything even resembling a hint in reduced operating costs.

While this may sound overly idealistic, you have but to look around you to find that considerable savings were accomplished by these installations; and the recruiting of safety, maintenance and accounting aid will give you additional "salesmen" to complete your selling job.

E. J. Gesdorf: I just want to say in answer to Mr. Ritter's questions and differences of opinion that all of the nozzle design information I presented in my paper is backed up by the authority of the gear manufacturers who use this type of equipment. Now, they caution us against the fineness of spray. Fineness of spray can be overdone. As a matter of fact, they prefer to have the grease come out of nozzles in large globules and go onto that gear, rather than in the form of a fine mesh. I just wanted to explain that one particular point.

Stephen T. Kraft: With reference to mill bearings, why did you not mention any application of spray systems on babbit bearings?

E. J. Gesdorf: I did mention application of spray to blooming mill roll neck bearings. Roll neck spray is an application that is very practical and is being used in several steel plants.

Stephen T. Kraft: Most of the applications that you indicate are those which seem to be on open gearing at relatively low speeds. Do you have any experience in high-speed applications?

E. J. Gesdorf: I am trying to think of a specific application. We have had experience—and this comes from memory—that paper mills, a great many of them

for years and years ran at speeds below a 1000 fpm. Now, just like the steel industry, there is a strong tendency to speed up paper machines and get more production, and the speeds are exceeding 1000 fpm. As soon as the machine speed exceeds 1000 fpm it is necessary to resort to other methods of gear lubrication. The drip and pour methods are ineffective because of the terrific centrifugal force.

Wherever a paper machine is speeded up beyond 1000 fpm, spray lubrication is usually resorted to because spray will penetrate and get that lubricant on the gear face where it will do some good.

Stephen T. Kraft: Do you feel that in applying oil lubrication by the spray method it is more effective and more efficient than the normal re-circulating method of oil systems?

E. J. Gesdorf: No, I do not feel that this method of application will replace oil circulating methods. It is not intended for that. This type of equipment is intended to replace the drip and swab method on open gearing where very heavy residual type gear materials are used. There are some systems that will spray light oils. In fact, this equipment will handle anything from an engine oil on up to heavy gear lubricants, but application of spray with the lighter products is not too prevalent.

In other words, you can think about this kind of equipment as a gear coating device. Once the gear is coated, it will run for a period of time before it needs additional application of lubricant. It is an intermittent spray and not constant. But to answer your first question, roll necks are being sprayed, and we did have an illustration in the discussion.

Stephen T. Kraft: Is that on anti-friction bearings?

E. J. Gesdorf: No, this is on plain bearings.

C. E. S. Eddie: I would like to ask Mr. Gesdorf in connection with the blooming mill application, if when installing the spray system, is it necessary to change the design of the bearing due to scale guard application and so forth?

E. J. Gesdorf: Scale guards on this particular application are very important. You do have to have good scale guards, particularly on the bottom bearings. Without them, the job would be pretty much of a failure, I would say.

Arthur Sutphin: I would like to ask Mr. Gesdorf if he has made any studies in comparing the cost of maintaining the spray equipment as against maintaining the normal type automatic equipment where block valves and lines are not in such a vulnerable position during roll changes.

E. J. Gesdorf: That is one of the hazards of spray lubrication of roll neck bearings. When you start injecting nozzles between the roll neck and mill housing, you are vulnerable to damage and trouble from that category; but actually the jobs that have been in operation, have not made an undue amount of trouble.

Of course, the secret of the whole job is the method of installation. If the job is poorly installed, it is not going to be very serviceable and will not last very long.

I was thinking of an application at one of the eastern steel plants. A mill was converted to spray lubrication and the first attempt was not very satisfactory, because the installation mechanics did not take the time to do the job right. The nozzles were installed in a hazardous location and in a short time they were knocked off. The mill personnel were convinced that the spray method had enough merit to warrant trying it again. They improved the installation and were able to make it stick the second time. ▲

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Rolling Mill Slippers

. . . . slipper troubles are problems with which most rolling mill operators and maintenance men must contend . . . . correct design, proper lubrication, and specification of right material for service involved can reduce some of the trouble . . .

"DESIGN"

by F. J. GLEVE
Assistant Chief Engineer
United Engineering and Foundry Co.
Pittsburgh, Pa.

ONE cannot discuss the slipper design used on a universal spindle without considering the other members. A universal spindle setup is composed of the coupling half, the slippers and the spindle with its coupling heads. The coupling halves are mounted either on the motor shaft, pinion shaft or drive shaft, while the driven end coupling is mounted on the mill roll. The motor torque is transmitted either direct or through pinion stand and drives to the coupling half and spindles. The coupling with its tongue, or fish-tail as it is sometimes called, is subject to torsional stress on its rectangular section. The slippers receive the bearing load from the tongue on one side and transmit this load by bearing on the jaws of the coupling head.

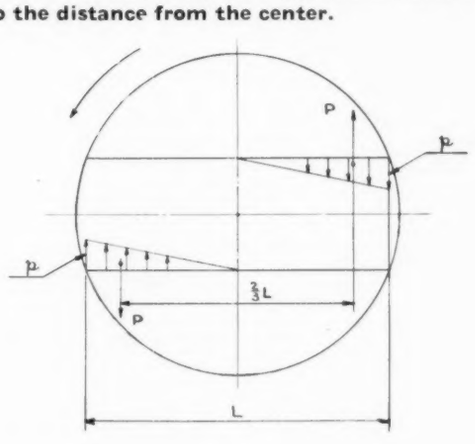
As can be seen from Figure 1, the loading of the slippers is of a uniform increasing load towards the outer edge. The resultant load will be located in the center of gravity of this triangle. The torque arm will then be approximately two-thirds of the length of the slipper. By determining the area of this triangle and multiplying same with the width of the slipper, same can be equated to the resultant pressure "P". From this equation, one can then determine the highest intensity of specific pressure at the outer edge of the slipper.

The jaws of the coupling heads are stressed in bending. They should not open up under this loading, particularly on a reversing type of mill, as on a blooming or slabbing mill, because this will give the slipper a blow-type impact which will forge out the slippers.

A rule of thumb for the preliminary design for the universal joint will make the thickness of the tongue about one-third of the coupling diameter while the outside diameter of the slipper will be about one-half the diameter of the coupling. After design has progressed far enough, analytical check of the strength should be made. One must also keep in mind that the torque available on blooming, slabbing and plate mills as well as on the roughing stands of a hot strip mill may be $2\frac{1}{2}$ times nominal torque. On flywheel-equipped mills, the peak load would have to be considered. On finishing trains and tandem cold mills, the torque available may be $1\frac{3}{4}$ and $1\frac{1}{2}$ times the nominal torque, respectively.

Another point which has to be considered here is the minimum roll diameter, which automatically determines the maximum coupling diameter. The mill operator and designer want to get as much life out of a roll as possible. This limitation is not on the driving end of

Figure 1 — Load intensity on slippers increases in proportion to the distance from the center.



$T = P\frac{2}{3}L$

$p = \frac{2T}{L}$

$P = \frac{p}{2} \times \frac{L}{2} \times W = \frac{1}{4} pLW$

P = TOTAL PRESSURE ON EACH SIDE
L = LENGTH OF SLIPPER
W = WIDTH OF SLIPPERS
T = TORQUE
p = BEARING PRESSURE IN #/SQ IN.

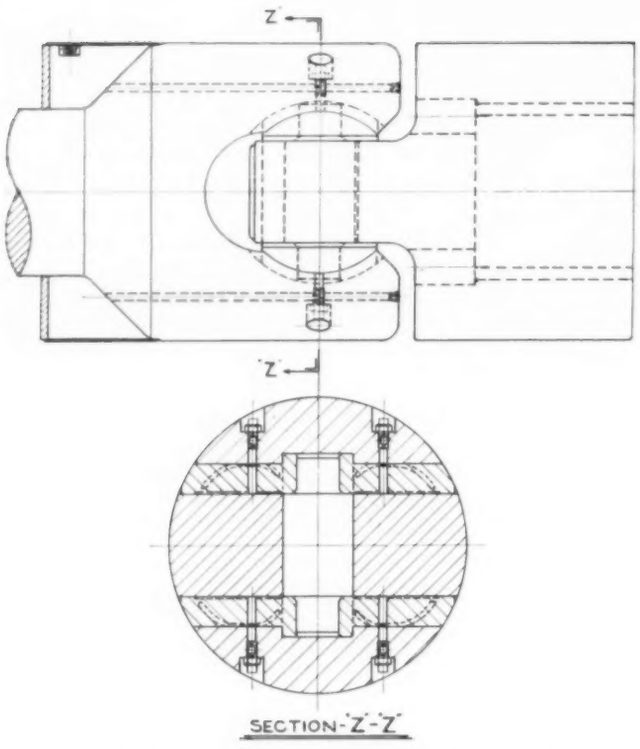


Figure 2 — This typical slipper design uses oil lubrication.

the spindle; there we are able to help ourselves as the center distances on twin motor drives or pinion stands are greater than the roll diameter.

The coupling and spindles are made mostly of forged steel and this makes replacement expensive. Therefore, the slipper is considered expendable. Nevertheless, the designer has to weigh all three members carefully to provide for the best performance of all three. The proper loading on the slipper and the material selected for same will give long wear. The spindle balance should be made sufficient but not excessive in order to put less load on the slippers. Small spindle angles will also give longer service than larger spindle angles encountered on high lift mills. In the latter case, a greater amount of sliding takes place.

The material we are using on slippers is a high tensile 110 manganese bronze, SAE No. 430B, which has an ultimate tensile strength of 120,000 psi, yield strength equal to 63,000 psi, elongation 15 per cent, and Brinell hardness of 225. The real important physical property of the bronze selected is the compressive limit; that is, the compressive stress which will give a permanent set of 0.001 in. on a cube of bronze, one sq in. area x one inch high. The chemical composition is approximately 64 per cent copper, 6 per cent aluminum, 3 per cent iron, 24 per cent zinc and 3 per cent manganese. Slippers are sand cast. The width of same should be so selected to make it possible to machine four slippers in one machine setup. Also, slippers of plastic materials and others with plastics and reinforced with bronze are being used. We have no record of their performance.

Slippers have been and are being designed in many different shapes and arrangements, but the apparent survivors are the ones as outlined on Figures 2 and 3. We should also point out here that the opening distance between the slippers should not be excessive, but must be sufficient to permit easy entry of the tongue when roll changing.

On blooming and slabbing mills and plate mills, we use oil lubrication. See Figure 2. Four holes are drilled from the end of the spindle parallel to the spindle axis and each one is connected with a right angle hole, which in turn introduces the oil to the slipper. On the back side of the spindle head a welded steel container is attached oil-tight to the spindle by welding. This is then filled with oil. A needle valve is there to adjust the flow.

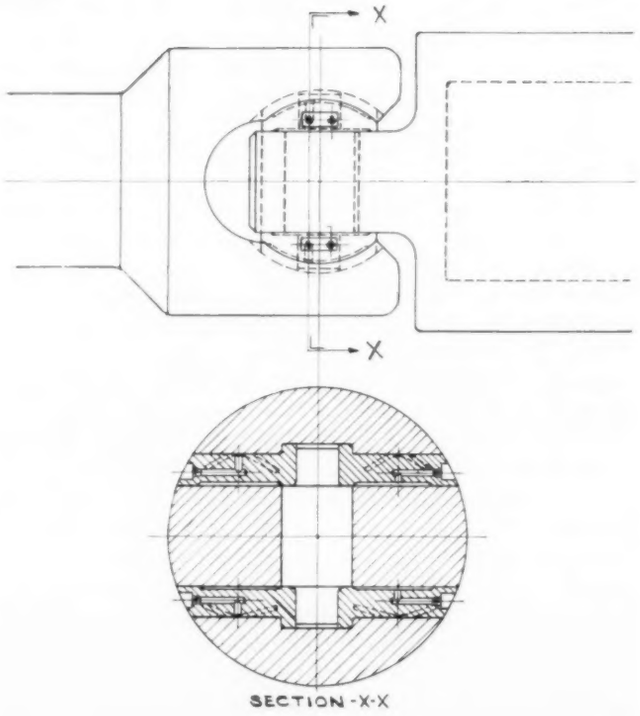
On hot strip mill stands, tandem and other types of cold mills, grease lubrication is employed. See Figure 3. Each slipper has two holes drilled on each end. One leads to the top surface while the second lubricates the inner surface. When lubricating this type of slipper, the mill has to be standing still.

Many different schemes of lubrication have been tried out, as for instance dropping lubricant on the universal joint from the outside and providing splash guards. Another one uses a rotating joint which in turn feeds a lubricating arrangement similar to the oil arrangement. The rotating joint is fed by lubricant pump at regular intervals.

For tandem mills and other cold mills, the gear type spindle has been introduced and makes the lubrication somewhat easier. We must understand that in the case of a universal spindle and particularly the slipper, they are exposed to centrifugal force which prevents the lubricant from staying put. Oil used should have extreme pressure characteristics and should have also good adhering qualities. The grease used should be of extreme pressure quality and also have good adherence to contacting surfaces.

In conclusion, we want to mention the use of slippers and universal spindles on vertical mills, levellers and pinch rolls, etc., on which the slipper design may vary, as well as its retention. The design problem remains the same.

Figure 3 — This typical slipper design uses grease lubrication.



"MATERIALS"

by R. J. SEVERSON
Assistant General Sales Manager
Ampco Metal, Inc.,
Milwaukee, Wis.

HOW many slippers did you replace today? Perhaps none. Maybe they were replaced yesterday. Or, if not, you are probably planning on doing so next week at the latest.

And how did the universal spindle bearing segment—the so-called slipper, or the set of segments fail? Were they badly worn, or were they galled, or were they squashed out of shape or did they just plain break?

There is only one way that a slipper should arrive at a point where it needs replacement. That should be by a process of gradual wear until the resultant excess clearance in the universal coupling give rise to the telltale "slipper slap." And even after the first appearance of such "slap," the slipper should have enough impact resistance to stay in service until production loss due to downtime can be held to a minimum.

If the above description of satisfactory slipper life is typical to your experience, then you are fortunate. If not, you have plenty of company.

Recently we had the opportunity of performing a metallurgical investigation on 60,000 lb of used aluminum bronze slippers! They came from various mills and were originally supplied by several bronze foundries. Each of the slippers was classified as to type of failure. They were carefully analyzed to check chemical composition, metallurgical structure, casting quality, uniformity and mechanical properties.

Almost half (45 per cent) of the used slippers had broken in service.

Almost without exception, the slippers which had broken in service exhibited low impact values due primarily to poor metal structure. These slippers never had a chance. Some of them, in fact, were so brittle that it appeared as though they had broken on being rolled into the pod.

A few of the slippers appeared to be broken or fractured by a fatigue type of failure. In such cases, wear characteristics seemed to be satisfactory. Such fatigue was probably caused by a flexing deformation of the slipper due to high torque loading.

Approximately 8 per cent of the used slippers showed signs of galling and high wear during service. This could have been caused by very poor lubrication practice, but since most of these checked rather low on the hardness scale (116 to 130 Brinell, 3000 kg, 10 mm) it was probably the alloy which was at fault.

Another small percentage (5 per cent) seemed to have distorted greatly as though they had just given up under load. This was confirmed during test by finding a low elastic limit of compression. Subsequent chemical analysis indicated that this was the result of either poor initial alloying proportions or subsequent loss or burn-out of original alloy mix due to faulty melting techniques.

Expressed in its simplest form, this all adds up to the fact that many slippers being sold today just do not have what it takes to give satisfactory performance.

Figure 1 — These slippers failed in service.

What should you look for in a slipper before you buy it? It is not tensile, yield, elongation and hardness. These properties are only indicative. What you really want is:

Wear resistance to give longest possible life but still remains expendable so as not to cause undue wear on jaw or spade of the spindle.

Impact resistance high enough to take a reasonable degree of slap, without breaking after excessive clearance develops.

Fatigue life of a degree which safeguards against breakage when subject to slipper flexing.

High loading carrying ability or an elastic limit of compression which will withstand the concentrated unit loadings which occur at increased operating angles.

Low coefficient of friction which affords protection in case of lubrication failure.

Figure 2 — Proper specification insures long slipper life.

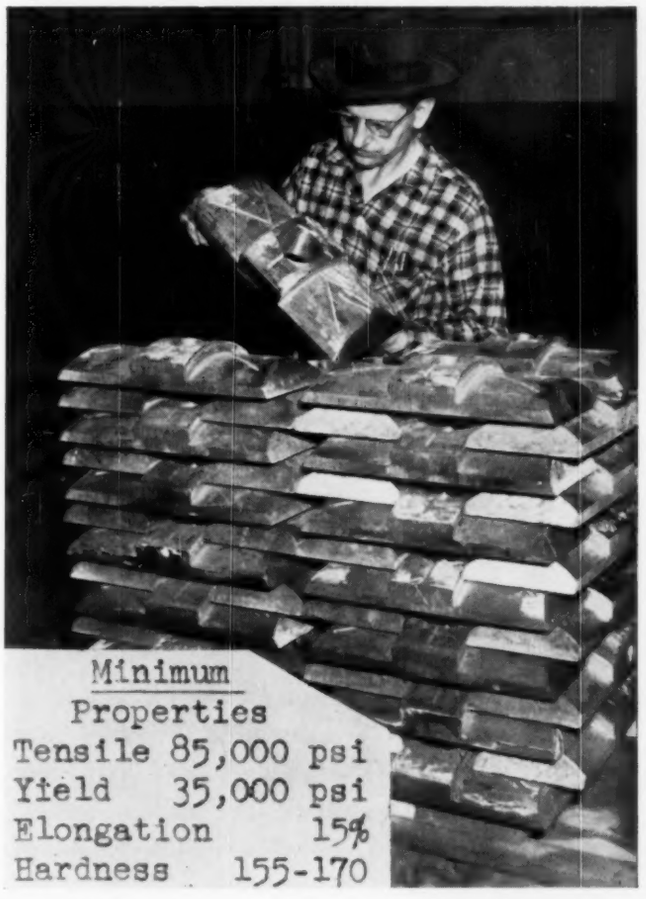


TABLE I
Typical Physical Properties ASTM-B Bronze Type

	Tin-lead bronze 144-3B	Hi-tensile brass (manganese bronze 147-8C)	Aluminum bronze 148-9C	Aluminum bronze recommended
Tensile strength, psi	35,000	110,000	80,000	90,000
Yield strength, psi (0.5 per cent)	16,000	60,000	31,000	38,000
Elongation, per cent	18	12	14	18
Brinell	*(1) 65	*(2) 212	(2) 180	(2) 165
Rockwell	72F	96B	88B	85B
Elastic limit compressive, psi	13,000	60,000	30,000	41,000
Shear strength, psi	18,000	53,000	51,000	56,000
Izod value, ft-lb	6	12	14	25
Fatigue, psi	16,000	20,000	31,000	33,000

* (1) 500-kg load. * (2) 3000-kg load.

Is all this obtainable in any one slipper material? It is not at least on today's metallurgical know-how.

However, as in practically all other pursuits in life—one can make a satisfactory compromise. The evidence however points to the fact that in the majority of cases the compromise being made is not the best obtainable.

Generally speaking, the choice of slipper material is limited to tin-lead bronze, high tensile brass (sometimes called manganese bronze) and aluminum bronze. Strength characteristics are as shown in Table I.

Tin-lead bronze which was popular years ago for slipper material is seldom encountered today. About the only attribute it has for slipper service is a low coefficient of friction which gives added protection in the case of lubrication failure. It of course would never wear the spindle, but it is obviously lacking in other properties necessary to current operating demands.

High tensile brass (manganese bronze) has the highest loading abilities but may be too hard for ideal mating characteristics with the spindle. It has the poorest coefficient of friction of the three types of alloys and is hazardous to use if there is any liability of lubrication failure. It has fair to good impact resistance, but a poor fatigue life and will, therefore, break under flexing conditions. Being a brass it is subject to stress cracking. Heavy sliding loads tend to spall the surface. It has an advantage in being a lower cost material and for this reason is often found in original equipment.

Aluminum bronze is currently the favorite slipper material. When properly made it well deserves such position. It is amazing, however, to find some mills still merely specifying "aluminum bronze" on their purchase orders. As such they can receive within a given shipment lot aluminum bronze alloys varying from so soft and ductile that a piece can be bent back double on itself—to so hard and brittle that a casting dropped from shoulder height will shatter as a piece of glass.

However most mills have learned to buy aluminum bronze to a specification. The most commonly encountered one is ASTM-B-148-9C. When dealing with a reputable supplier, the use of this or similar specifications results in a rather high degree of satisfaction. Many suppliers, however, do not have the experience, melting equipment or metallurgical control necessary to produce to these specifications, even though the ingot which they purchase may be proper for the specification. It must be remembered that aluminum bronze is highly susceptible to variations in analysis, to partial burn-off of some of the alloying members, to cooling rates and to heat-treating temperatures. If you are purchasing aluminum bronze slippers to a specification and they are not resulting in satisfactory service life, it might be well to have your own metallurgical staff run periodic physical checks. Another suggestion would be to occasionally cut test bars from worn slippers to see what actual values your supplier has been furnishing. This is of course "after the fact" but may have a helpful effect on persuading your supplier to drive for uniformly good properties meeting specifications on the material he furnishes you.

Furthermore, over the years it has been determined that by closer control and heat treatment that the commonly encountered specification type of aluminum bronze can be improved upon. A desirable lowering of hardness and increase in elongation and impact resistance can be brought about simultaneously with an increase in yield and compressive strengths. This is apparent from the data presented in Table I. Formerly a betterment in one of these sets of properties brought with it a detrimental effect on the others.

Now—keeping in mind the characteristics or behavior expected from each of the various types of alloys—we should be able to prepare a chart similar to that shown in Table II. From then on any compromise can at least be an educated one.

TABLE II
Rating Considering Selected Factors as Noted—ASTM-B Bronze Type

	Tin-lead bronze 144-3B	Hi-tensile brass (manganese bronze) 147-8C	Aluminum bronze 148-9C	Aluminum bronze recommended
Friction	1	4	3	2
Slipper wear	4	3	2	1
Load carrying	4	1	3	2
Jaw wear	1	4	3	2
Impact	4	3	2	1
Fatigue	4	3	2	1
Poor lubrication	1	4	3	2

It is observed that when considered in its entirety that the recommended improved aluminum bronze is by far the best compromise.

How do you order the aluminum bronze recommended? As yet no specification has been written calling for this combination of chemical and physical properties. However, if you order ASTM-B-148-9C but also specify that the elongation will have a guaranteed minimum of 15 per cent in 2 in., a hardness range of 155 to 170 Brinell and a yield strength of 35,000 psi at 0.5 per cent elongation under load as a minimum, the other properties will automatically fall in line, that is, provided you are supplied what you order. ▲

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Designing a Large Tonnage Continuous Casting Plant

. . . . elaborate studies have been made on continuous casting plants for the steel industry . . . . this paper summarizes factors which must be considered, and evaluates the advantages and disadvantages of various applications . . . .

CONTINUOUS casting may generally be defined as the making of a casting many times the length of the mold in which it is cast. The casting so produced may be of a cross-section suitable for further processing to finished products with fewer operations and on smaller and less costly equipment than would be required for conventionally cast ingots. In effect, it is possible to cast finishing billets or slabs directly from molten metal, and to eliminate the blooming or slabbing operation with the subsidiary related operations such as transfers, soaking, cropping and scarfing.

In a new installation, the reduction in equipment and space should be considerable. In addition, the possible savings through lower operating costs due to eliminated operations appear most attractive. A third and major saving expected is in the remarkably high yield of usable semi-finished material from a given weight of molten metal, as there is little or no cropping loss.

These theoretical advantages have been obvious for many years, and a great host of inventors and development engineers have devoted their talents to this field with widely varying degrees of success. Hundreds of patents have been granted for continuous casting processes and related apparatus, and millions of dollars have been spent in experimental and pilot plant programs. A few usable methods have been developed to the degree necessary for commercial application, and gradually semi-continuous and continuous casting have become common in the nonferrous metal industries where the various processes now in use include the following:

1. Asarco[1]*
2. Alcoa[2]
3. Junghans[3]
4. Inco
5. Properzi[4]
6. Hunter-Douglas[5]
7. Tessmann

In the steel industry, there have been many attempts at continuous casting, aiming at casting both semi-finished products and finished sheet or strip. While many of the processes used in these attempts have produced small quantities of usable material, the goal of commercial success has been considerably more elusive than in the nonferrous field. The major intermediate goals on the way seem to be remarkably consistent as we read the reports on the various machines:

1. Supplying molten metal to the machine at the proper rate and temperature. Most of the attempts fail at this level.
2. Casting a product of acceptable quality.
3. Cutting and discharging the material cast.
4. Operating dependably and consistently.
5. Operating profitably.

* Numbers refer to Bibliography at end of article.

The literature[6, 7, 8, 9, 10] on the subject gives for the currently operating machines fairly complete and frank information on their performances on items 1, 2 and 3 above, while items 4 and 5 are not usually discussed at all. However, the best information available indicates that there are at least six continuous casting machines throughout the world now casting steel on a commercial basis and operating profitably. Several others are operating with sufficient technical success to warrant continued effort toward dependable and profitable operation. The important thing is that the continuous casting process has finally made the grade in the steel industry and is operating at a profit in several separate installations. From the experience on these machines, it is possible to draw the know-how and the techniques for designing and operating future continuous casting plants. With the feeling that the basic pilot plant work is finished, we can proceed with some degree of confidence to the next step in the gradual evolution of the process; the design of a large tonnage continuous casting plant for steel. The term, "large tonnage," is used rather loosely to differentiate from the specialty steel field rather than indicating any specific tonnage rate.

BASIS FOR DESIGN

In planning the general design of a new continuous casting machine, it is advisable to consider several factors before setting up the specifications:

1. The design should be based on the most successful of the existing machines for the type of product desired. If several machines qualify as successful, the best features of each may be used.

2. The design should be based primarily on existing operating techniques. If these do not exist for the specific types of steel to be run on the proposed machine, an experimental program is in order, both to develop satisfactory techniques and to determine reasonable production rates.

3. The design should be based on existing production rates. If the proposed machine will be substantially larger than any which exist, considerable care should be used in extrapolating production rates.

4. The design must allow for development. While for immediate purposes the design must provide for profitable operation based on present production rates, it must be borne in mind that development occurs in relatively new processes at a remarkably high rate. Today's production rates may be raised considerably before the machine comes into full production, and will certainly be raised through the years as experience results in improved techniques and equipment. Therefore, the design must also provide for the future, so that the proposed machine will not become obsolete or require drastic conversion to keep up with normally expected development. There is often a conflict between the requirements of present and future economical operation, which must be resolved by reasonable compromise. The past record of such compromises is that the future has not received sufficient attention and that most of the existing machines have either been considerably modified from their original form or now require modification in such items as over-all height, length of cooling zone, machine speed, main drive, motor size, cooling water volume, cutoff equipment, etc., in order to attain higher production rates. Of course, if the future is given too much weight in decisions on design, the cost of the machine may become too high for present economical operation, and the proposed machine may never become a reality.

5. The design should be integrated with usual melt shop practices, requiring no unusually long ladle time or excessively hot metal.

With these points in mind, let us consider the design of a large tonnage continuous casting plant for steel. So far as is known, most machines for steel are of the oscillating mold type, and further discussion will be confined to this type.

CONTINUOUS CASTING MACHINE DESIGN

The first step in designing a large tonnage continuous casting plant is to investigate the present and potential capacity of a single strand machine of a type suitable for production of the desired product. Let us assume that this product is low carbon rimming, semi-killed, and killed steel slabs. In a recent paper, Jaicks, Kraay and Tenenbaum[11] report on an experimental program in slabs of these types, and conclude that the present operating limitations are:

1. Machine speed—35 in. per min.
2. Slab width—40 in.
3. Slab thickness—6½ in.
4. Casting rate—70 tons per hr for killed or semi-killed steels, and somewhat less for rimming steel.
5. Machine availability—50 per cent, based on 1-hr casting, 1-hr clearing the machine and setting up for the next run.
6. Metal availability—from a 10-furnace section of an open hearth shop, 60 per cent.
7. Annual capacity—180,000 tons.

The proposed machine must be designed to operate profitably under these conditions, but must also be designed to take advantage of improvements in practice and equipment as they occur. No doors should be closed which might in the future limit the machine's production to less than its potential capacity.

To estimate the potential capacity of the proposed machine, let us take the above limitations singly, and consider the effect on each of them of development at a reasonable rate:

1. *Machine speed—35 in. per min*—This is now limited by the appearance of corner cracks and bleeds at higher speeds, and by possible breaking out of metal below the mold at speeds over 45 in. per min. An additional limiting factor may be internal quality of the material cast, which in some cases appears to be related to machine speed. The appearance in the experimental data of an occasional run at considerably higher speed without cracks or breakout suggests that our understanding of this problem is far from complete. An investigation of the effects of mold length, mold taper, and methods of increased cooling in the lower end of the mold might well result in a substantial increase in permissible speed. Without taking into account the possibility of invention of devices or development of methods not now known, it is felt that provision for average machine speed of at least 50 in. per min is absolutely

necessary and that another 50 per cent higher average speed should be planned for if it can be done without excessive original cost. There is good precedent for this 50 per cent allowance for increased average casting speed in the records of past performance of most of the currently operating machines.

2. *Slab width—40 in. maximum*—So far as is known, the widest steel slab continuously cast to date has been 32 in. wide. The selection of 40 in. as the maximum width was based on the opinion that this was the greatest increase in width that could be reasonably justified without actual experience. In designing the proposed machine to cast 40-in. wide slabs, it would be wise to avoid any design features which would limit the future slab width to less than that required for 48-in. strip. After experience has been gained in casting the 40-in. width, the question of design width should be again considered with the thought of possible extension to the wide slab field of 70 to 80 in.

3. *Slab thickness—6½ in.*—This should be considered as an optimum, rather than as a maximum thickness. If for reasons of coil weight and slab heating furnace length it is necessary to design for thickness of 8 in. or so, a lengthening of the cooling area below the mold will be required and a reduction in casting speed may be necessary to keep the molten metal crater depth within limits. Approximately the same casting rate in tons per hour will result.

4. *Casting rate—70 tons per hr for killed or semi-killed steels, somewhat less for rimming steel*—This rate is figured from the foregoing limitations of 40 x 6½ in. slabs at 35 in. per min. If it is figured instead from the proposed 48 x 6½-in. slabs at 50 in. per min, the potential casting rate is 120 tons per hr, which may be considered a reasonable rate for the machine in the absence of fundamental change, but with normally expected development and operating experience.

5. *Machine availability—50 per cent*—For the present type of operation, handling a single ladle of steel in a run of perhaps an hour duration, then stopping, clearing the machine, and setting up for the next run, this is probably a reasonable figure for a machine similar to the one on which the estimate was based. The factors of design, development of operating techniques, improved operating materials, furnace practice and production scheduling may all act to raise this figure. There is nothing in the machine itself which limits the duration of a run or the availability of the machine. In the nonferrous industry, continuous casting machines operate at machine availabilities somewhat over 90 per cent, stopping only for weekend maintenance and size change. If problems of metal supply and refractories can be overcome, it is reasonable to expect that steel casting machines can also operate around the clock. Provision for this possibility should be included in the design.

6. *Metal availability—60 per cent*—This is based on a study of a 10-furnace section of an existing open hearth shop and is based on machine availability of 50 per cent. The average waiting time after machine setup was estimated at slightly over one hour, reducing estimated machine operating time to approximately 30 per cent of total time. The factors mentioned above under machine availability are also involved here, and with experience the figure should be improved. For an electric furnace shop, we might expect a wide variation depending on the number of furnaces and the average heat time. For an oxygen converter shop, the more regular productive cycle would probably give a metal availability figure as high as 90 per cent.

7. *Annual capacity—180,000 tons*—Going back through the individual items above, and using the product of the reasonably expected maxima, the potential annual capacity is found to be approximately 700,000 tons.

The design, then, must provide for immediate profitable operation at an annual production of 180,000 tons and should be capable of handling 700,000 tons per year without major modification. Where machine dimensions are a factor in production rate, they must provide for the expected increased rate, and where auxiliary equipment suitable for the present production rate is installed, space should be left for larger units or additional units for the expected future requirements.

The next step is the calculation of the proposed machine's major dimensions. Vertical dimensions will be dependent on the factor of slab thickness, machine speed and slab length or weight requirements. Since it is essential that the slab be completely solidified before cut-off, molten metal crater depth for the 6½ x 48-in. slab is figured at a machine speed of 50 in. per min and a suitable factor of safety is added, giving 30 ft as the minimum safe vertical distance between mold and cut-off. To this height must be added allowance for cutoff (10 ft), allowance for discharge equipment (5 ft) and the length of the maximum slab desired (assumed 30 ft). All this comes to 75 ft as the height from the bottom of the machine to the mold or to the operating floor. Another six ft must be allowed for the mold itself and for the molten metal distributing means, giving a total of 81 ft to the bottom of the ladle.

Horizontal dimensions of the machine need be only enough to provide for working space around the pouring operation and for temporary storage of the required operating equipment. An area 20 x 40 ft is adequate for the machinery, but is insufficient for convenient operation. An area 30 x 60 ft should be sufficient for the operating floor of a single-strand or two-strand machine and 40 x 60 ft for a four-strand machine. Other floors can be considerably smaller.

If we consider as one "casting unit" the continuous casting facilities required to cast in approximately one hour the product of a steelmaking furnace, then the size of the furnace heats and the size of the castings required will determine the number of strands in each casting unit. The number of casting units will be determined by the tapping cycle and the number of the steelmaking furnaces. In general, calculation can be based on a one-hour pouring period followed by 30 to 40 min downtime, during which solidification of the last portion of the previous heat is completed, the machine is cleared and set up for the next heat, including any size change. It may be seen that in general two casting units will be required to handle the product of an oxygen converter tapping on a 45-min cycle until such time as techniques are worked out for continuous operation. For electric furnaces tapping on a three to four-hour cycle, one casting unit can surely handle the product of one furnace, and can handle the product of two furnaces if heats are tapped perfectly spaced. In an open hearth shop, with furnaces tapping on a 10-hr cycle, in theory

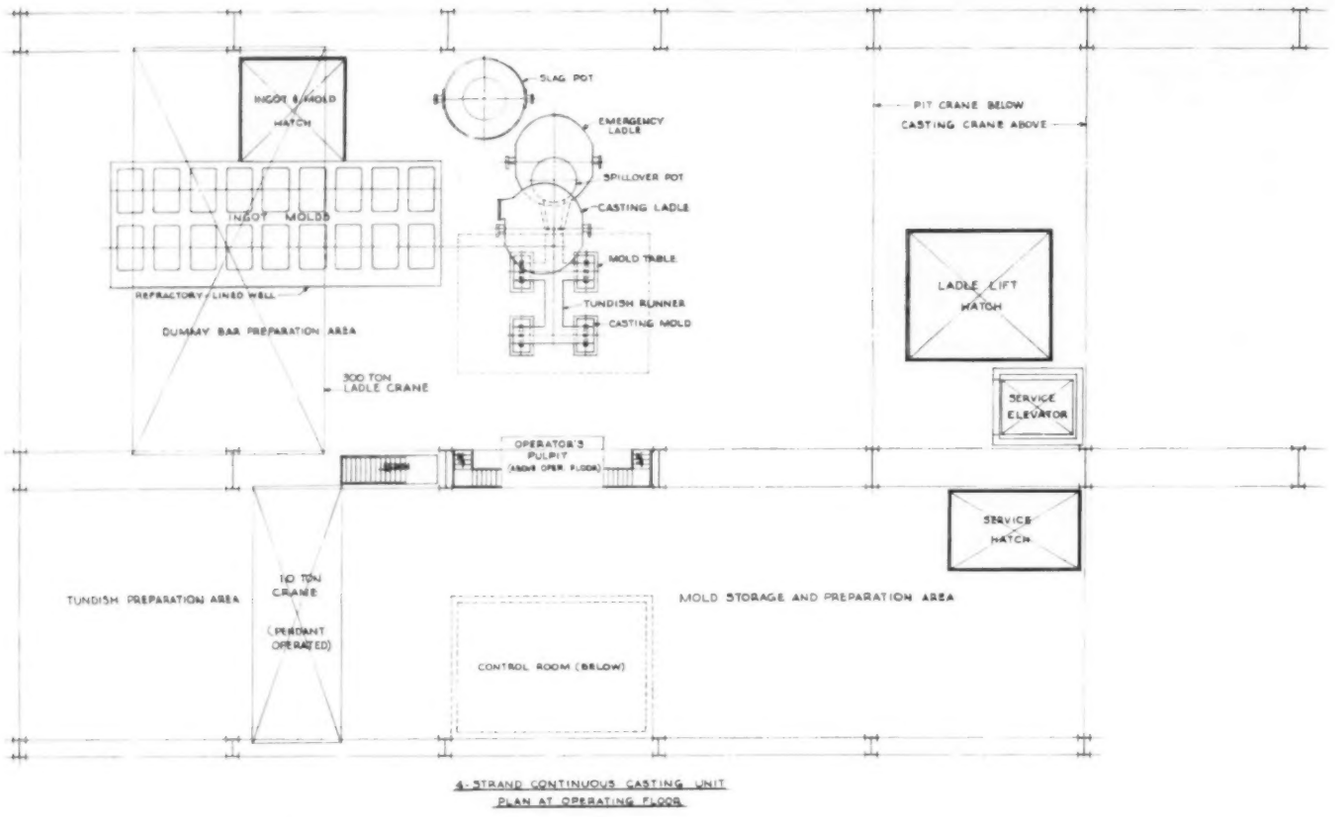


Figure 1 — This tower type four-strand continuous casing unit was designed to handle 250-net ton heats.

one casting unit should handle the product of six furnaces if tap times could be perfectly spaced, but the inevitable bunching of heats will probably require one casting unit for each three or four furnaces.

This conception of an open hearth shop, with a series of multi-strand casting machines making slabs of various sizes and types of carbon steel, is quite different from what was proposed a year or so ago for Inland's No. 2 open hearth shop, that being one 2-strand machine in a tower on the south end of the shop. The change in thinking has been in part the result of our reports on the Russian[10] experience with multiple unit slab machines in open hearth shops. They have reportedly found the handling of molten steel from the furnace to the casting machine to be greatly simplified if the casting machine fits under conventional open hearth pouring crane facilities, even though a deep pit is required. Obviously, there is abundant room for compromise between the pit type and the tower type of construction. The relative ease of molten metal handling in the pit type of construction will no doubt be a factor improving metal availability, but where local conditions are not favorable for deep pits, a compromise may be reached preserving many of the advantages of each type.

Several drawings have been prepared showing shops of various types for large tonnage operation.

OPEN HEARTH SHOP

The open hearth furnace is the work-horse of the large tonnage steel producers, contributing about 87.5 per cent of the nation's steel in 1956. While the open hearth is least adaptable to continuous casting of any of the present steelmaking methods, because of both the erratic tapping schedule which increases the difficulty of maintaining a high utilization of the casting unit, and the generally larger heat sizes which require either multiple ladles or complex multi-strand machines, its superior position with respect to annual tonnages produced makes it mandatory that consideration be given to adapting continuous casting to this type of operation. In defense of the alliance of the open hearth and continuous casting, it can be said that the Russians are now operating the two together successfully at both Sulina and Krasnoe-Sormovo,[10] and that they plan by 1962, to produce 20 per cent of their annual 60,000,000 ingot tons with similar, although somewhat larger, facilities. Bifurcated spouts for casting steel into two ladles are in use in this country and abroad, and there are at least three 4-strand casting machines in successful commercial operation in Europe, one at Mannesmann Huttenwerke in Huckingen, Germany,[6] another at Boehler in Kapfenburg, Austria,[7] and the third at Cail Works in Denain, France.[8]

As stated previously, successful continuous casting from this relatively unpredictable open hearth source requires that a casting unit be provided for each three or four furnaces. In addition, facilities should be provided for casting a full heat of conventional ingots, of a size small enough to be recharged in the furnaces, and with sufficient taper for crane stripping. These are to be used in case of furnace or casting machine emergencies.

Space requirements for such a casting unit must first be determined. Figure 1 shows a 4-strand casting unit designed to take 250 net ton heats, and to produce slabs such as 36 to 40-in. wide by $6\frac{1}{2}$ in. thick at a casting rate of 70 net tons per hr per strand. The annual capacity of this unit would be about 700,000 net tons.

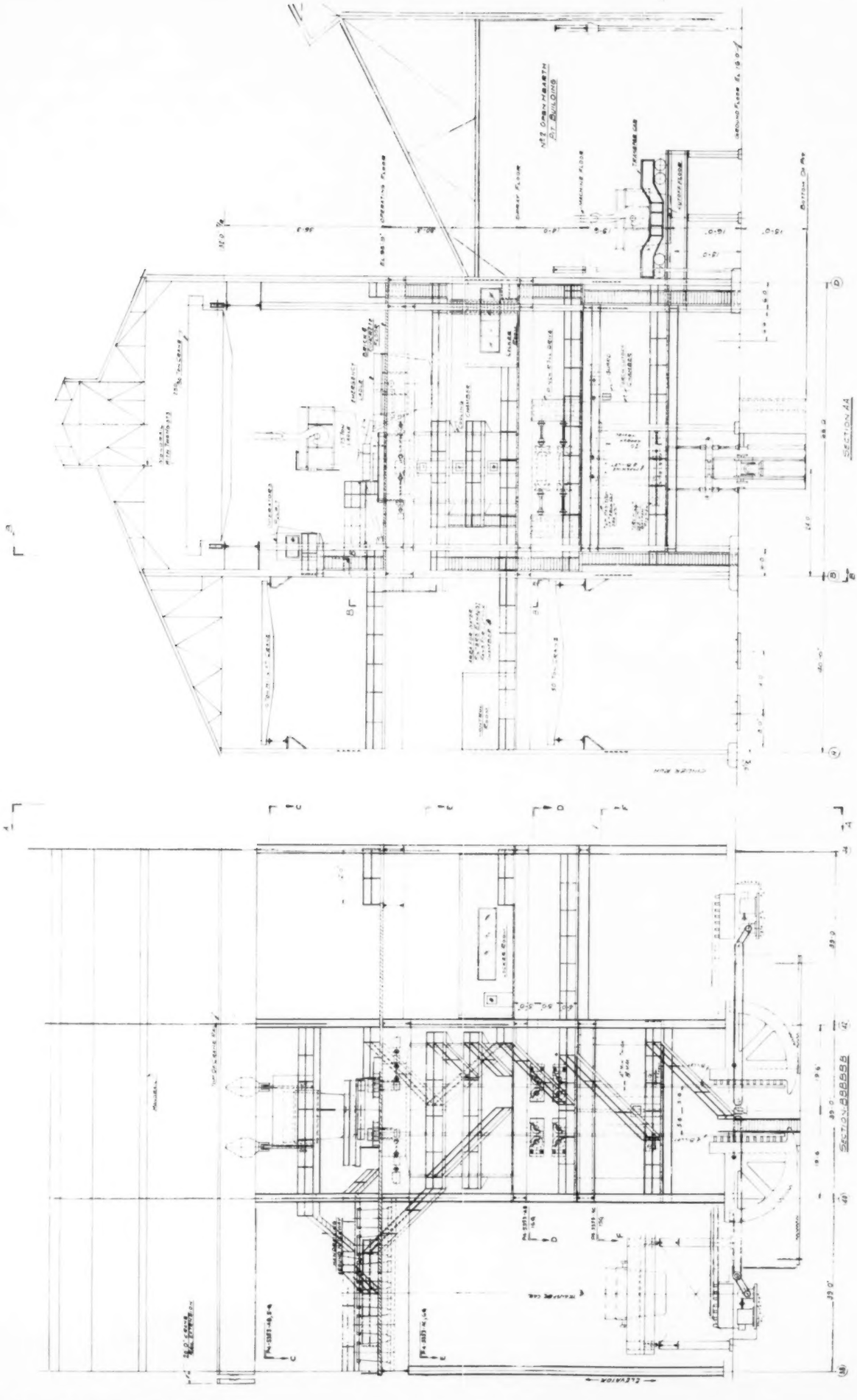
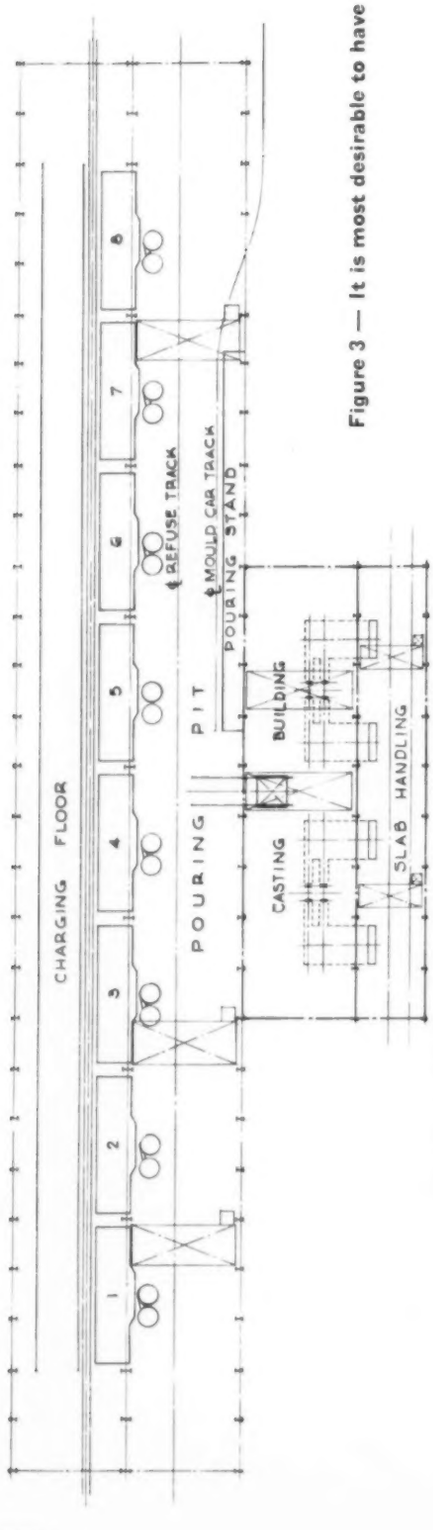
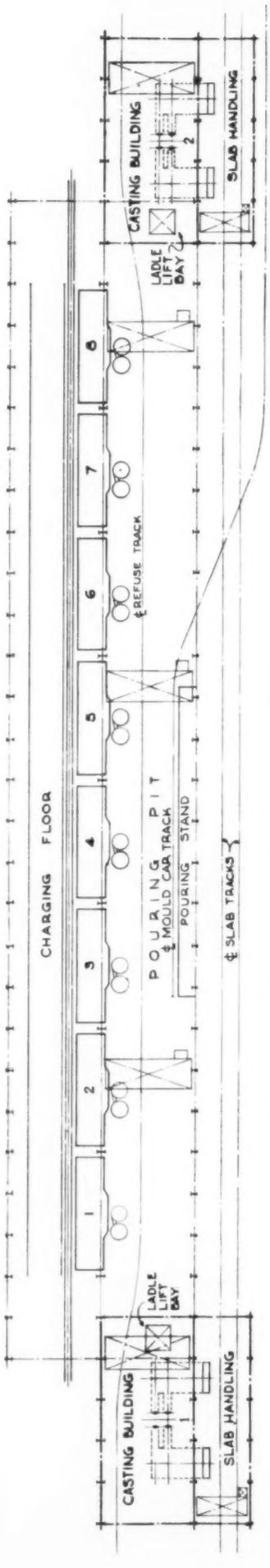


Figure 2 — Annual capacity of this unit would be about 700,000 net tons.



GENERAL ARRANGEMENT - UNITS IN ADJACENT PARALLEL BUILDING

Figure 3 — It is most desirable to have unit in line with the pit building.



GENERAL ARRANGEMENT - UNITS IN LINE WITH POURING PIT BUILDING

The operating floor area required for this machine is about 40 by 60 ft with a somewhat larger area required at the discharge level. Figure 2 shows an elevation of a unit of this type. The requisite space will not usually be available in an existing open hearth pit building, so that it becomes necessary to find this space in a near-by location. Environmental factors will determine the exact location of the units in any particular case.

The most desirable arrangement is to have the unit in line with the pit building, as shown in Figure 3. The principle advantage of this arrangement is that no intermediate ladle transfer equipment is required. This reduces materially the all-important finish-of-tap to start-of-pour time, resulting in a potential increase in machine capacity over the arrangements in which an intermediate ladle transfer is required.

Greatest advantage may be taken of this arrangement if the machine can be located in a deep pit with the operating floor at or near the level of the open hearth pouring pit floor. The pit crane can then serve both the furnaces and the casting machine, and the conventional ingot casting facilities can be used for disposing of a heat in an emergency. This results in a major savings in capital equipment, and also decreases the operating costs.

A tower type machine with this arrangement will require a secondary ladle crane at a high level on a runway overlapping the pouring pit crane runway at the ladle lift bay. Conventional ingot molds should be provided at the operating floor level for emergencies. This will require an auxiliary trolley on the high level crane of sufficient capacity to handle both ingots and molds rapidly to ground level. In addition, this crane must handle slag pots, and on occasion emergency ladles and spillover pots.

An arrangement having the casting unit in an adjacent parallel building, as shown in Figure 3, also lends itself

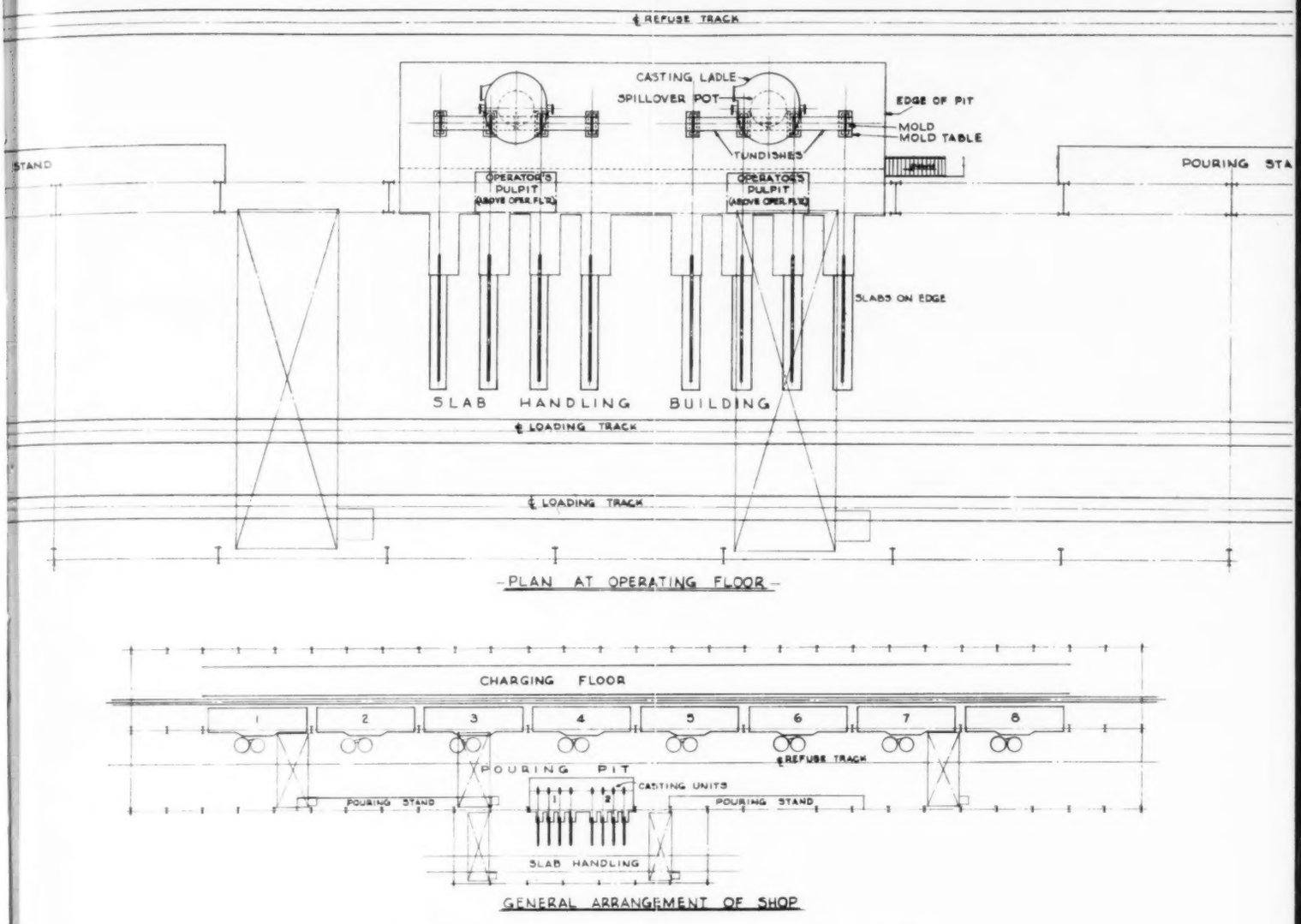


Figure 4 — This shop is ideally located with respect to the furnace.

to either the pit or tower type machine, although again the pit type machine will give the shorter ladle transfer time. In either case, the transfer is accomplished by a ladle transfer car. The transfer car must be so designed that it can handle not only the steel pouring ladle, but the emergency ladle, spillover pot and slag pot. It must also be capable of passing under the pit crane runway, and provide adequate clearance over any tracks.

With the pit type machine, the steel ladle can be supported during the cast by the transfer car. The tower machine will require a high-level ladle crane, as in the in-line arrangement, in addition to the ladle transfer car. This latter is the arrangement proposed for the Inland No. 2 open hearth shop. This was an entirely satisfactory and workable arrangement. It was rejected because:

1. A single casting unit did not provide sufficient capacity to support Inland's projected expansion program.
2. The environment at the 24-furnace No. 2 shop did not permit the installation of a second casting unit in an acceptable location. Figure 4 shows two 4-strand pit type units in an ideal location with respect to the furnaces which they serve. Tonnage rates and product sizes would be the same as for the tower type machines already discussed. A minimum of equipment is required for handling emergencies when they arise, since the conventional ingot molds are conveniently located in line with the casting machines. This arrangement will most frequently be adaptable to existing open hearth shops.

CONVERTER SHOP

Figures 5 and 6 show a pit-type arrangement of an oxygen converter with two single strand continuous casting machines. The plan of operation for such an installation would be to take alternate heats on each machine. This would give a typical cycle of one-hour for casting and 30 to 60 min for clearing the machine and setting up for the next run. The same plan arrangement would be suitable for a tower type operation.

Annual capacity of such a shop would approximate 500,000 tons of slabs with a converter of 70 tons rating, based on one-hour per heat and 90 per cent availability of the converter.

At some future time, when improved refractories will permit truly continuous operation, with successive heats pouring into a single machine as long as size and grade requirements permit, replacement of the ladle car over each machine with one capable of carrying two ladles will quite simply solve the metal handling problem.

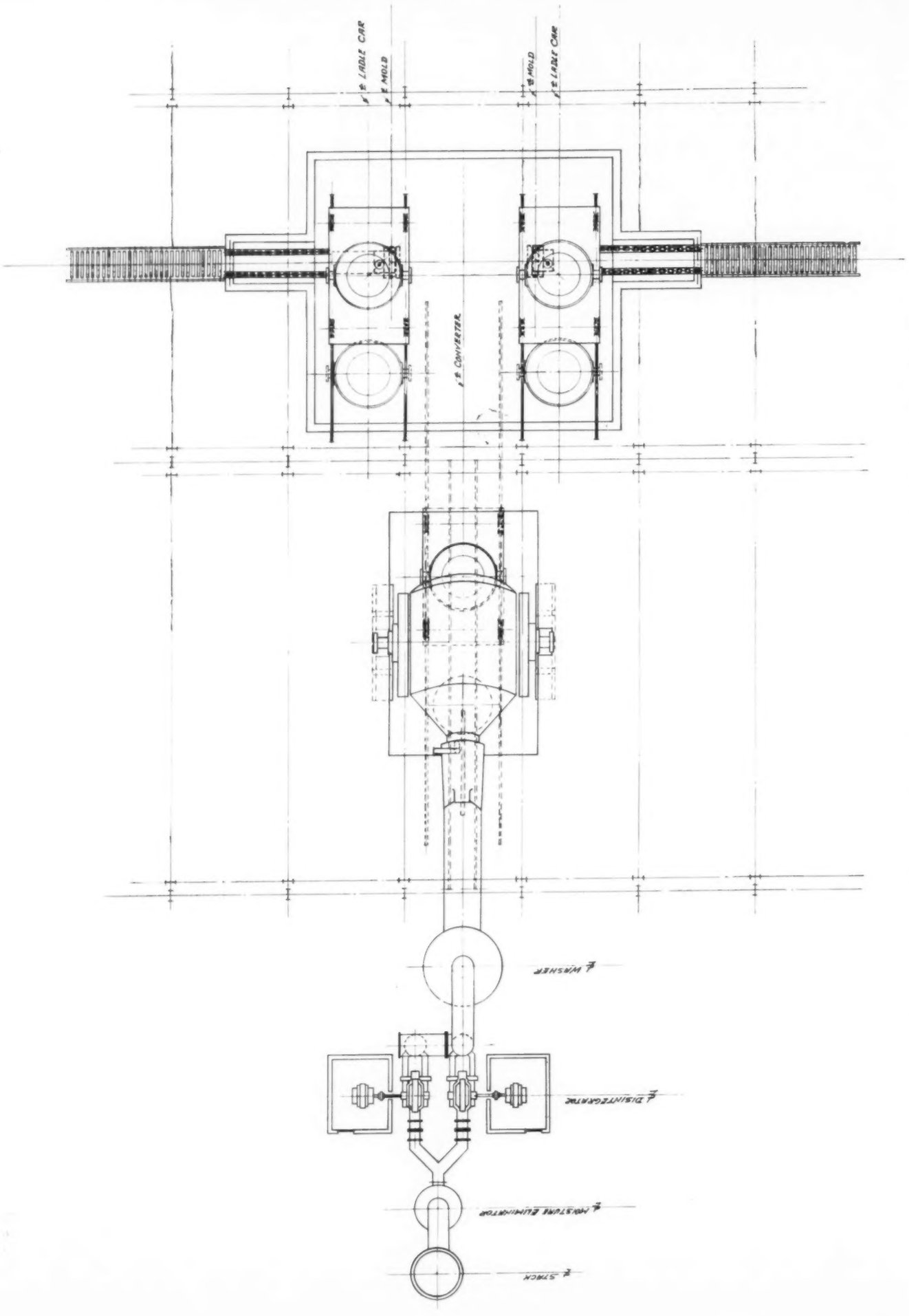


Figure 5 — Layout shows the oxygen converter combined with the continuous casting machine.

ELECTRIC FURNACE SHOP

Figures 7 and 8 show a tower type arrangement of a four-strand continuous casting machine for casting 3 to 6-in. square billets, using two 50-ton electric furnaces for metal supply. Based on a four-hour average melting cycle, the annual capacity of the shop is approximately 175,000 tons of billets per year. While this shop was designed for carbon steel production it is capable with very minor alterations of producing alloy and stainless billets at a rate which will be somewhat lower due to the longer melting cycle. If the preferred product is slabs, a similar arrangement using a single strand slab machine may be used, with the same annual capacity. In either case the operating cycle on the casting machine would be approximately one hour for casting and 30 min or more for clearing and setting up the machine for the next heat.

METALLIC RECOVERIES

Figure 9 shows a general comparison of the metallic recoveries of continuous casting with those of conventional production methods with open-hearth steelmaking. Due to differences in recoveries depending on the type of steel cast and on the operation of the individual shop, typical figures have been used which may be replaced by more appropriate figures for the study of any specific case. The major items of interest in these typical figures are:

1. To make 100 tons of slabs, conventional processing requires 19 tons more metal in the ladle, and 21 tons more metallics in the furnace charge.
2. For 100 tons of slabs, there is a net saving of four tons in the total metallics which must be furnished to the steelmaking unit in favor of continuous casting.
3. Continuous casting eliminates a large part of the

Figure 6 — In this installation alternate heats would be taken on each machine.

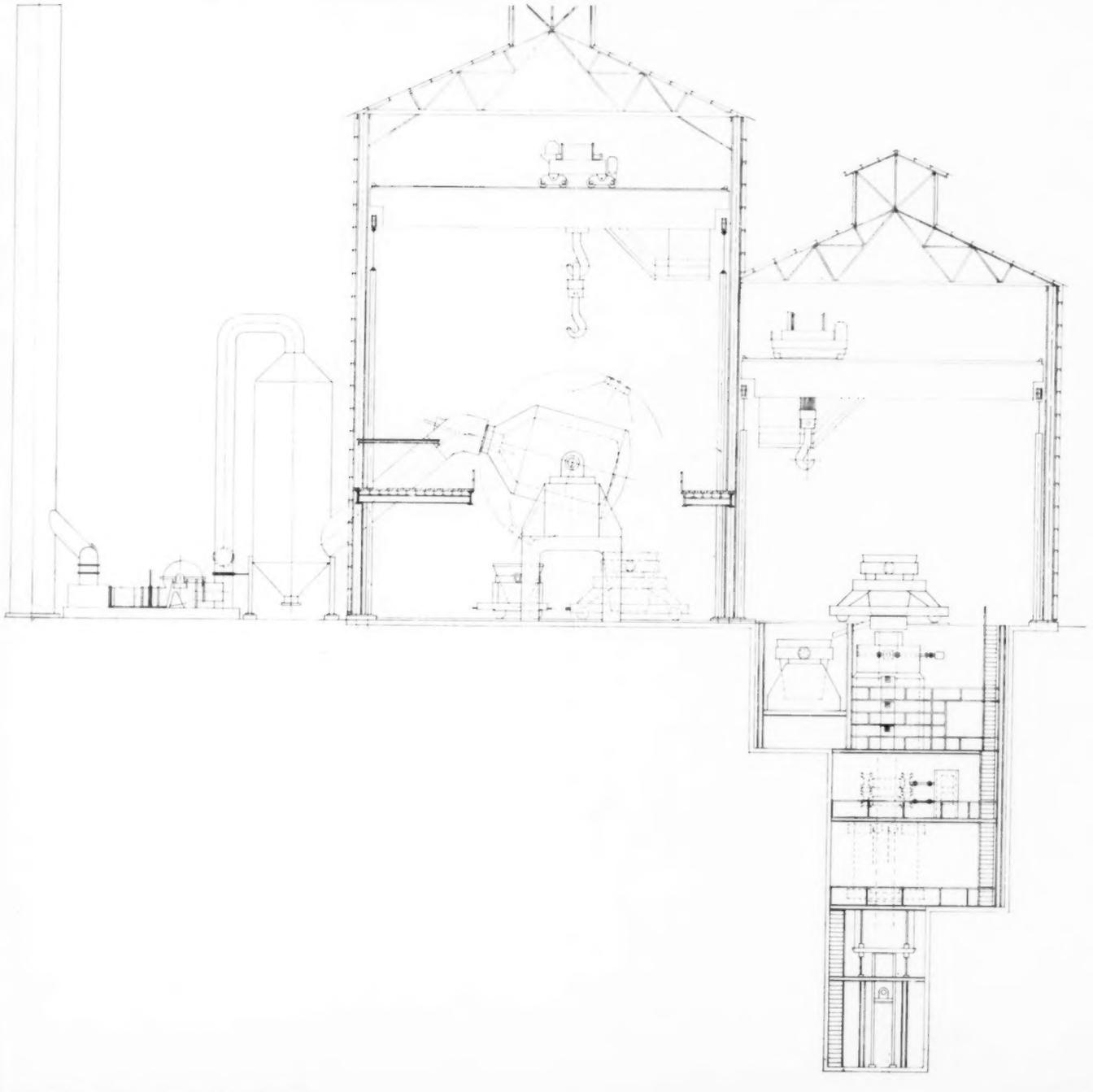


Figure 5 — Layout shows the oxygen converter combined with the continuous casting machine.

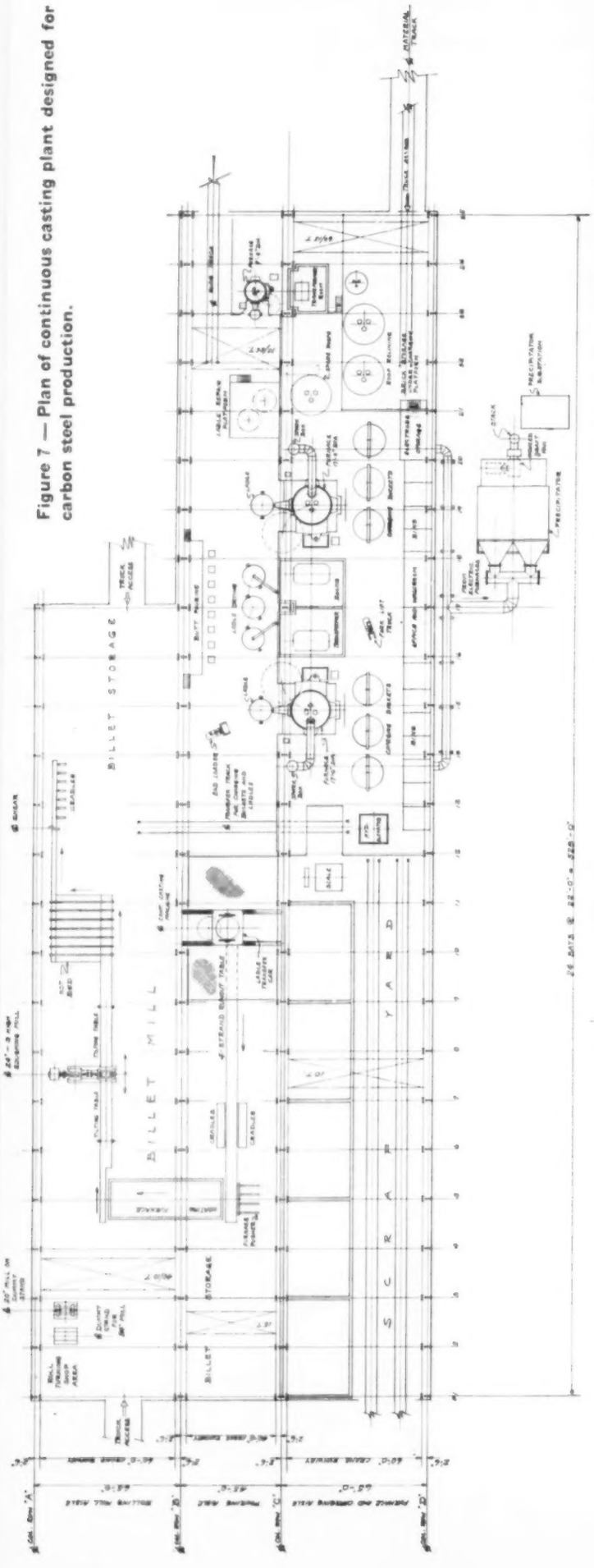


Figure 7 — Plan of continuous casting plant designed for carbon steel production.

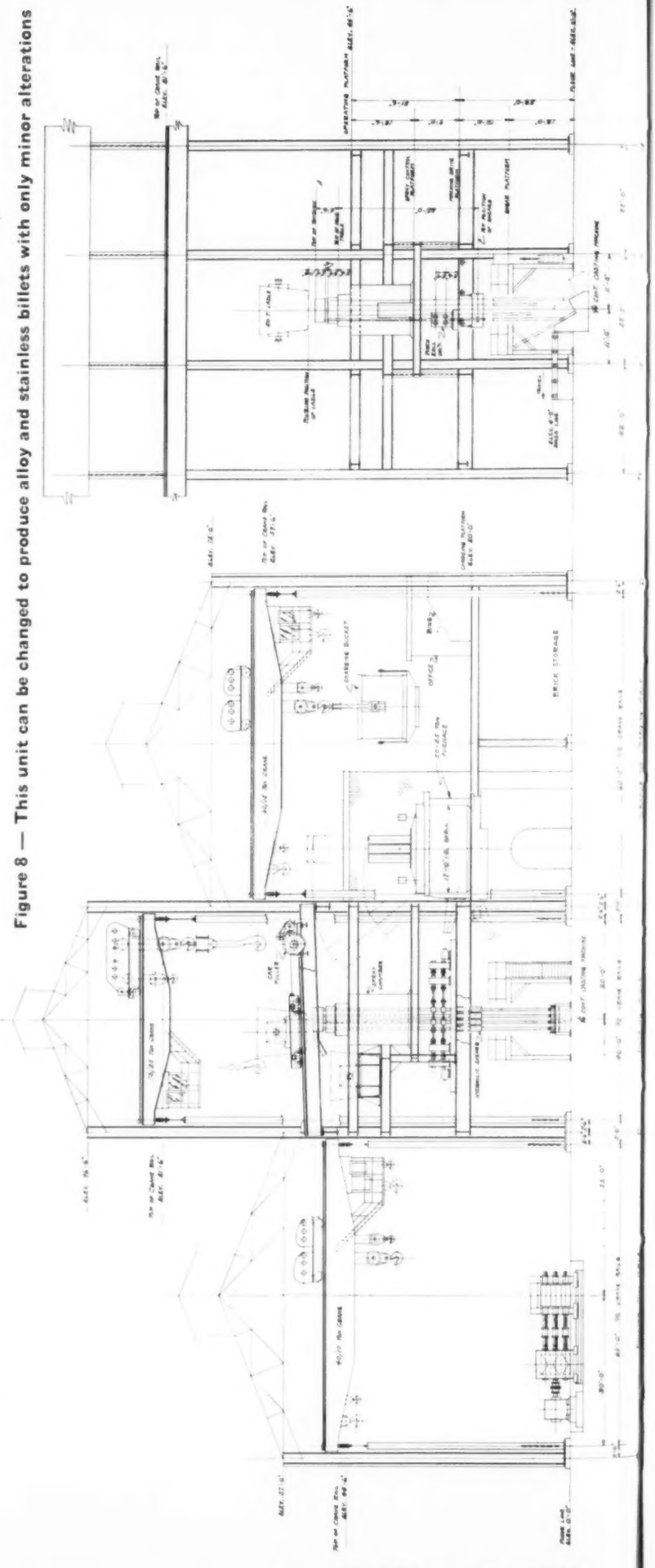


Figure 8 — This unit can be changed to produce alloy and stainless billets with only minor alterations

scrap resulting from cropping, which normally returns to the steelmaking unit for remelting. If steelmaking facilities are to operate at maximum capacity, this scrap must be replaced by purchased scrap which is comparatively inferior in quality and high in cost. To balance this apparent loss, it can be seen that a given amount of steel in the ladle will produce about 18 per cent more slabs when continuously cast.

If steelmaking is not at capacity, the loss of cropping scrap is more than balanced by the greater productivity of the continuous casting process. If we use the same weight of hot metal in our charge for each 100 tons of slabs produced (69 tons for 50 per cent practice for conventional processing), we gain by continuous casting a net reduction of four tons in the purchased scrap required, as well as an increase of hot metal ratio to 59 per cent with corresponding economies in metallics cost and heat time, all without increasing the quantity of hot metal used.

CAPITAL EQUIPMENT COMPARISON

In planning a new installation, it is interesting to compare the buildings and equipment required for continuous casting with those required for conventional processing. This can most easily be done by eliminating those items which are common to both, and listing for each only the items remaining.

For continuous castings:

Casting machines, with controls and accessories.
Casting buildings or pits.
Ladle cranes or cars.
Mold and equipment, working and storage area.
Water recirculating and cooling system.

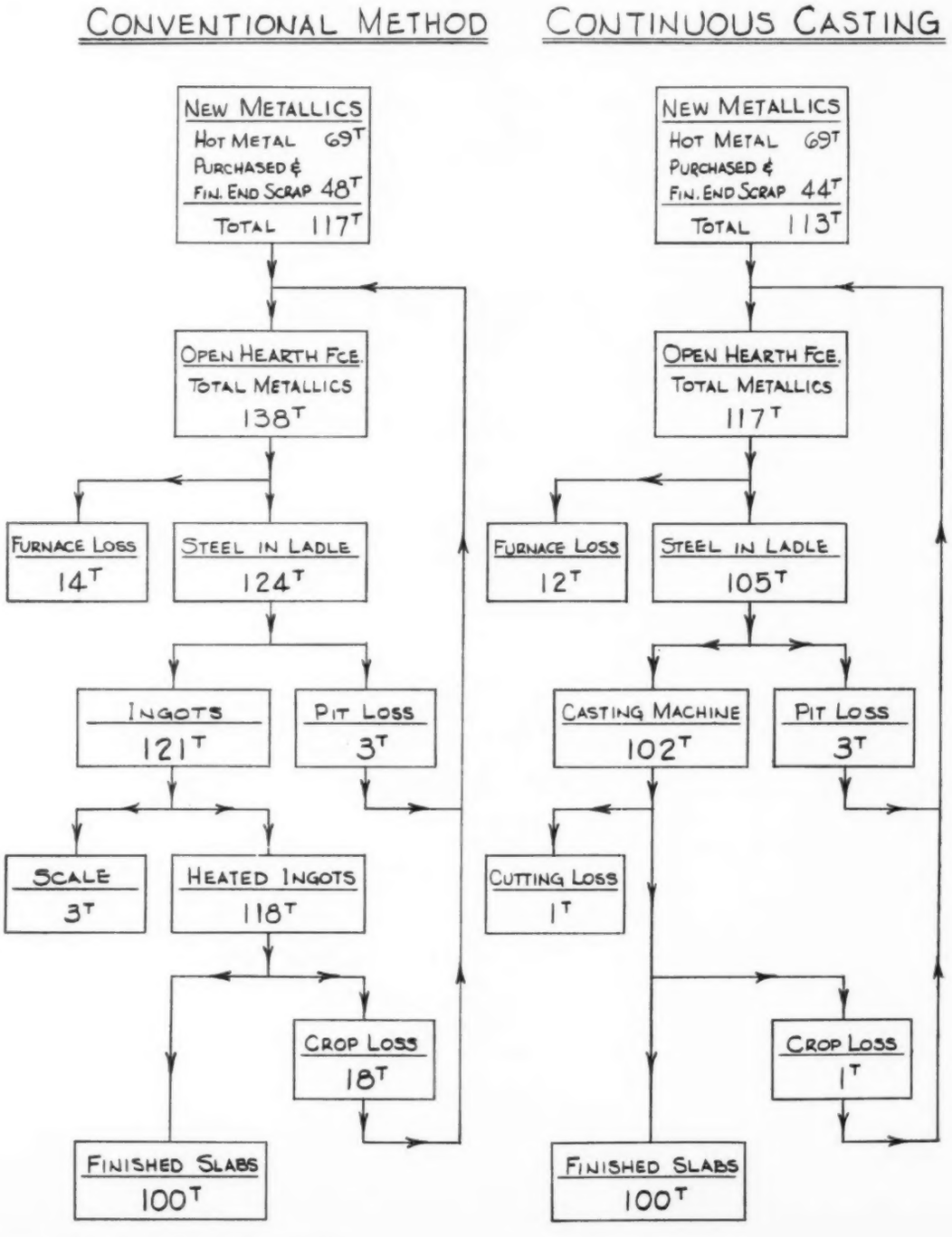


Figure 9 — Metallic recovery with continuous casting is estimated to be higher than with conventional methods.

For conventional processing:
- Mold preparation yard or building, with crane, coating equipment and hot tapping facilities if applicable.
- Mold foundry and storage area, with cranes and equipment.
- Stripper building with crane and equipment.
- Ingot buggies and locomotive.
- Soaking pit building, with soaking pits, controls, ingot transfer buggy, cranes, cover cranes, tong cranes.
- Blooming or slabbing mill, controls, pulpit, building, cranes, motor room building, cranes, shears, crop conveyors, roll turning equipment.
- Approximately 15 to 20 per cent larger steelmaking facilities.

EVALUATION

Shown below is a brief statement of the continuous casting process' advantages and disadvantages as brought out by the preceding discussion:

Advantages
- Apparently lower capital costs.
- Apparently lower operating costs.
- Fewer personnel required.
- Less plant area required.
- Greater productivity with any given metal supply.
- Conservation of metal.
- Reduction of processing time.
- Reduction of in process inventory.

Disadvantages
- Vertical height requires pit or high molten metal lift.
- Multiple units are required for large heats.
- Untried and undeveloped for large tonnage operations.

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CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

No June Meeting.

BUFFALO SECTION

No June Meeting.

CHICAGO SECTION

Tuesday, June 3, 1958
Golf Party
Gary Country Club
Gary, Ind.

CLEVELAND SECTION

Thursday, July 17, 1958
Golf Party
Elyria Country Club
Route U. S. 20 West of Elyria

DETROIT SECTION

Saturday, June 21, 1958
Summer Dinner & Dance
Dinner, 7:00 P. M.–9:00 P.M.
Dance, 9:00 P.M.–12 P.M.
Hotel Statler, Detroit, Mich.

LOS ANGELES SECTION

No June Meeting

PHILADELPHIA SECTION

No June Meeting

PITTSBURGH SECTION

Monday, June 9, 1958
Golf Party
Sunnehanna Country Club
Johnstown, Pa.

ST. LOUIS SECTION

No June Meeting.

SAN FRANCISCO SECTION

No June Meeting.

UTAH SECTION

June 7 and 8, 1958

Two Day Joint Meeting with The Colorado Fuel and Iron Corp.
Registration, June 6, 1958

Hotel Colorado, Glenwood Springs, Colo.

YOUNGSTOWN SECTION

Wednesday, June 18, 1958
Golf Party and Dinner
Tippecanoe Country Club
Youngstown, Ohio

Scrubber Combines High Collection Efficiency with Economical Operation

A MAJOR addition in the field of wet scrubbers for dust collection—the Turbulaire-Doyle Scrubber—is now being offered to industry by Western Precipitation Corp. under a license agreement from the original developer, The Consolidated Mining and Smelting Company of Canada Ltd. (Cominco). Perfected by Harold Doyle of Cominco and backed by years of application in Cominco's own diversified plant operations, the scrubber impinges dust-laden gas at high velocity into a pool of scrubbing liquid. The high velocity impingement causes the gas and dust particles to penetrate deeply into the liquid bath, thus accentuating the wetting action and producing unusually high dust collection efficiencies, even on particles so small they are in the fume range.

Plant applications on a wide range of gas cleaning and cooling applications have shown highly satisfactory results at a relatively low power consumption, low liquid-to-gas and low liquid-to-dust ratios, indicating that this new type of scrubber should prove to be a major advancement in the field of gas cleaning equipment.

RANGE OF APPLICATIONS

To date, various metallurgical and chemical plants of Cominco have some 70 scrubbers of this type operating in many diverse fields of application. In metallurgical operations, these scrubbers are being used successfully on gases from roasters, dryers, screening operations, smelting, crushing, refining and ventilation of various transfer points (elevators, bins, etc.). In Cominco's chemical plants, the scrubbers are being used for a wide range of cooling, scrubbing and cleaning applications.

Being recovered in the form of liquid concentrates and slurries are such varied materials as iron oxide, phosphate rock, lead sinter, coal and coke dust, as well as lead fume, arsenic fume, phosphate fume, ammonia and volatile fluorides. Considering the high efficiencies obtained (97 to 99 per cent), the pressure drop of 5 to 10 in. of water is moderate, and the low liquid ratio of 1 to 5 gpm per 1000 cfm indicate that the scrubber can be used advantageously even in areas having a low supply of water or other scrubbing liquid.

DESIGN

Basically, the unit consists of a sloping rectangular tank with impingement and eliminator sections separated by a baffle plate across the tank at right angles to the gas flow. The impingement section contains an overflow weir for controlling the fluid level and a gas inlet nozzle incorporating a cone for increasing the gas velocity. The major percentage of dust collection (or gas cooling) occurs in this impingement section.

GAS VELOCITIES

As the dust or fume-laden gases pass through the inlet duct, their flow velocity is accelerated by a conical nozzle centered in the throat of the duct and terminating just above the surface of the scrubbing liquid. The relatively high gas velocity produced by this jetting action causes the dust particles to drive deeply into the scrubbing liquid so that it is completely wetted, thus assuring intimate contact of the dust-laden gases with the liquid for high dust separation efficiency. (Or, when used for cooling, this jetting action assures efficient heat transfer and low outlet temperatures.) The scrubbing liquid overflowing the constant-level weir then carries away the dust and fume particles separated from the gases.

The eliminator section contains a baffle arrangement for drying the gases before they are discharged from the outlet port. Also located in this section is an inlet for introducing clean scrubbing fluid into the tank as dust-laden fluid flows out.

MATERIALS

Because of its relatively simple design, the scrubber is readily adaptable to various types of construction materials, thus facilitating corrosion-resistant design. Materials that have been used for construction include mild steel, stainless steel, lead and wood. Still other materials can easily be used where applications justify their selection. A complete unit to handle 15,000 cfm will measure about 6 ft wide by 8 ft high by 10 ft long, with dimensions of other size units being approximately proportional as cubic capacities are increased or decreased.

APPLICATIONS

Installations already in service show that, for comparable pressure drops, the Turbulaire-Doyle scrubber will operate at substantially higher efficiencies than most other wet collectors. Moreover, because of its basic simplicity, wide adaptability, low maintenance, lack of moving parts and low initial cost, this scrubber offers important advantages over other wet collectors or scrubbers now commercially available.

The field of application for these scrubbers is extensive, including many varied applications in such basic industries as mining and metallurgy, iron and steel, rock processing, chemicals, cement and many others. In all domestic industries the unit will be marketed through the nation-wide offices and representatives of Western Precipitation Corp., while Canadian sales will be handled by Western Precipitation's subsidiary Precipitation Company of Canada, Ltd., headquartered in Montreal. Where pilot plant studies are indicated, a package 500 cfm scrubber test unit is available for application studies. Experience has shown that these small units are helpful in establishing commercial size parameters, with performance of the actual commercial installation generally even better than that of the test unit operation. ▲

The Prevention of "Lighting Off" Explosions

by J. B. Smith, Chief Engineer, Factory Mutual Engineering Div.,
Associated Factory Mutual Fire Insurance Companies, Boston, Mass.

A RECENT study of 83 fuel explosions at heat-treat furnaces over a 10-year period showed that forty occurred during lighting-off. Of the forty, at least 25 were caused by one or more burner cocks being accidentally left open when the main gas valve was turned on.

All of these accidents were preventable. The problem is, of course, the human factor. Industrial boiler and furnace operation, depending as it does upon human operators, will never be entirely foolproof.

This article will describe a gas safety control system developed by the Factory Mutual Engineering Division Laboratories of the Associated Factory Mutual Fire Insurance Companies. Currently in use in many Factory Mutual plants, it provides a simple, efficient safeguard against one of the primary causes of such explosions: premature admission of gas to open burner cocks.

THE FM COCK SAFETY CONTROL SYSTEM

One type of the FM cock system is designed around three important units: a special gas cock, a checking pressure switch and an electric safety shut-off valve on the main gas line.

The FM cock is similar to normal gas cocks, except that it is equipped with two side outlets which furnish a small independent passageway that is open only after the main gas passage is completely closed. The cock is constructed (Figure 1) with a narrow key-way that permits either gas flow to the burners or flow through the side outlets, but not both.

This construction feature is important. It is gas or compressed air, supplied through the side ports of the cock, which furnishes pressure to energize the valve on the main gas line. This energizing force cannot reach the switch unless all burner cocks are turned off, owing to interior cock construction. It is therefore impossible to open the main gas valve unless the burner cocks are fully closed.

Cocks for this purpose are manufactured to particularly close specifications. In sizes up to 2 in., Factory Mutual approved cocks are manufactured by D. T. Williams Valve Co., Cincinnati, and W. J. Schoenberger Co., Cleveland. In sizes from 2½ to 6 in., the only Factory Mutual approved cock is the Nordstrom lubricated plug cock, manufactured by Rockwell Manufacturing Co., Pittsburgh. All cocks are equipped with integral handles and are suitable for manufactured, natural, propane and butane gases. The integral handles, combined with the quarter-turn (90-degree) operation of the cocks provide a visual check on cock position in addition to interior construction safeguards.

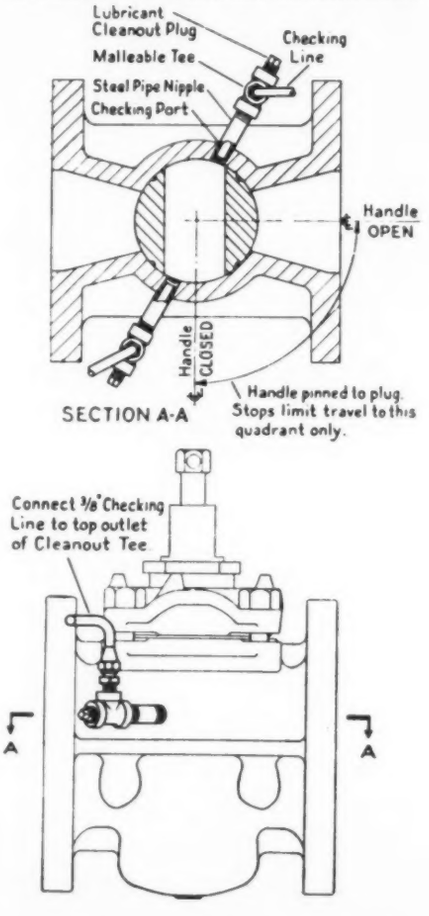
COCKS CONNECTED IN SERIES

The side ports of all cocks are connected in series with copper tubing. In a typical application where gas is used in the checking medium, one end of the line of tubing is connected to the main gas line on the upstream side of the main shut-off valve, the other to the checking pressure switch.

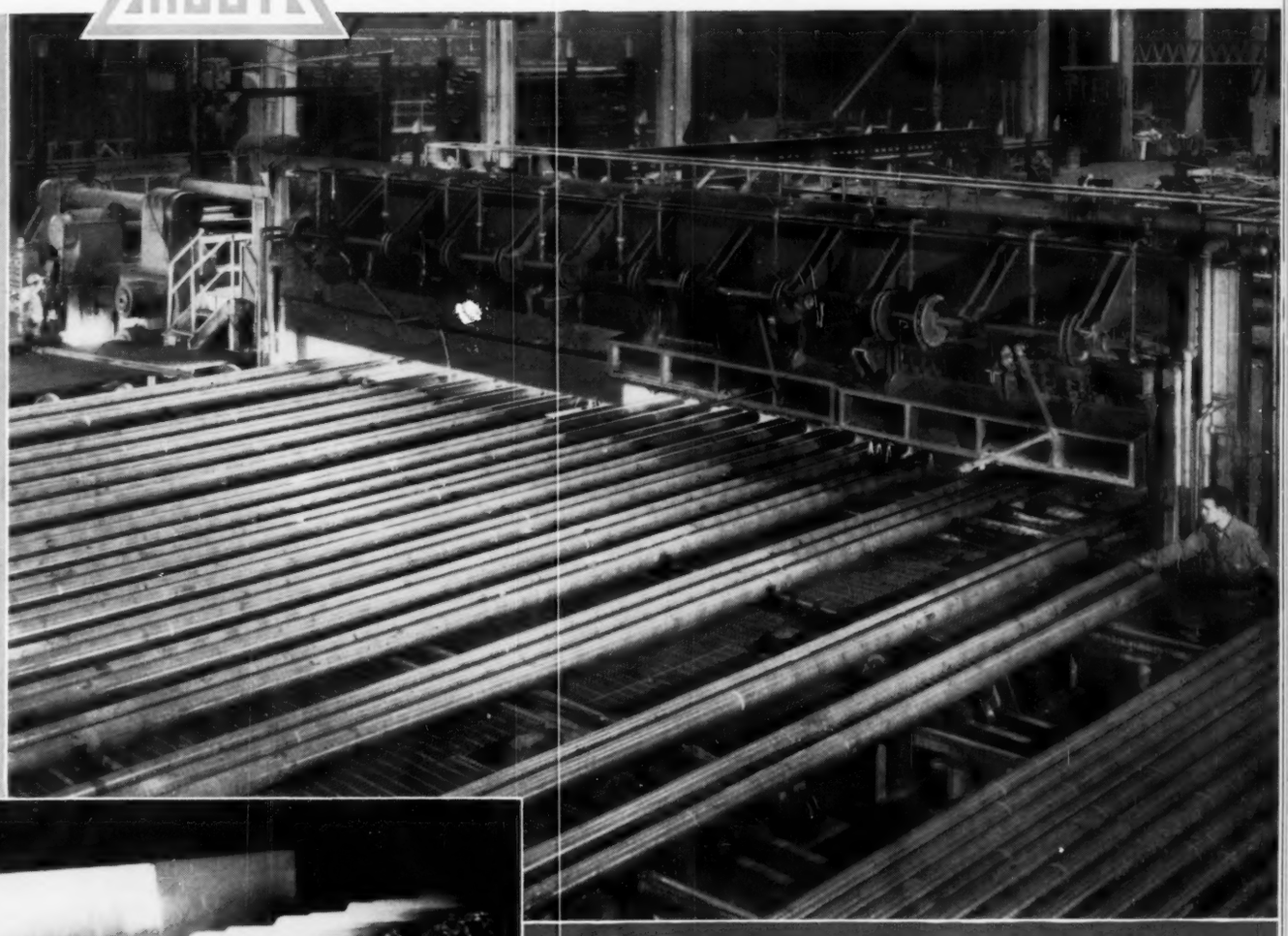
In lighting off, the operator first turns gas into the small tubing connecting the cock side ports. If the cocks are fully closed as they should be, gas flows through all cocks by way of the side ports and operates the checking pressure switch. This energizes the electric safety shut-off valve on the main gas line so that the operator can open it, which must be done by hand.

As soon as the electric valve is opened, gas flows into the burner piping and operates a low-gas-pressure switch which "shunts out" the checking switch. This second switch keeps the electric valve from closing when the individual cocks are opened to light the burners. It also furnishes the usual protection in case of gas pressure failure, being set to trip the main safety shut-off

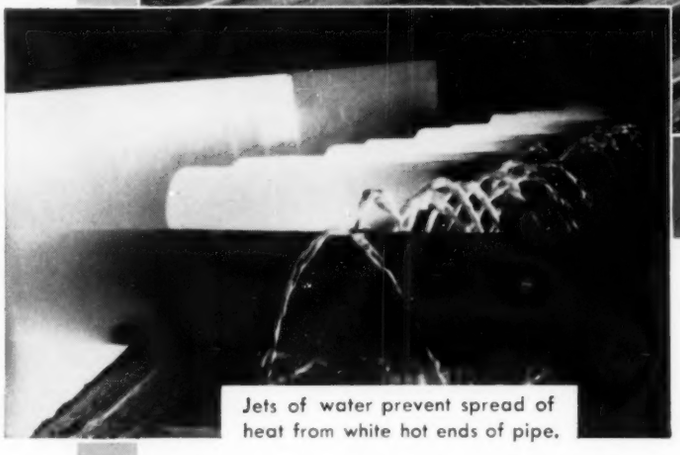
Figure 1 — Cock is constructed with narrow key-way that permits either gas flow to the burners or flow through the side outlets, but not through both.



New RUST UPSETTER FURNACE takes 3½" to 10¾" pipe



Upsetter Furnace at Seamless Specialty Mill, Jones & Laughlin Steel Corp., Aliquippa, Pa.



Jets of water prevent spread of heat from white hot ends of pipe.

A new slot type Upsetter Furnace for heating pipe ends prior to upset forging was especially designed and constructed by Rust Furnace Company for Jones & Laughlin Steel Corporation's Aliquippa seamless tube mill. It is the first upset furnace of its type and handles a variety of sizes of seamless tubing from 3½" to 10¾" in diameter. The pipe is used for deep wells.

Rust Furnace Company, serving the metallurgical industry since 1925, designs, constructs and places in operation all types of furnaces. The Company is equipped to meet any of your needs in the melting, reheating, or heat treating fields.

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valve in the event of dangerously low gas pressure.

A bleed orifice is required at the end of the line of tubing. It must be small enough to prevent gas escaping into the room at dangerous rates, and to allow pressure to build up and close the checking pressure switch promptly if there is a free passageway through the checking tubing, yet large enough to quickly relieve pressure and re-open the checking switch so as to transfer supervision to the low-gas-pressure switch.

COMBUSTION AIR BLOWER APPLICATION

In a combustion air blower system—the arrangement most frequently encountered in industrial plants — the checking pressure switch is operated by air pressure (Figure 2). A third pressure switch provides protection against failure of combustion air pressure, as well as assurance that the combustion air blower will be started in proper sequence when lighting-off.

The low-gas-pressure switch should be located in the burner gas piping so that there is no valve which can form a gas-tight barrier between it and the cocks. If such a valve is present, an additional pressure switch or a by-pass around the valve may be required.

Where automatic temperature control is by "high-low" or modulating zone control valves in the gas piping (Figure 3), it is customary to provide a shut-off cock on each side of each control valve to permit its removal for repairs. A valved by-pass is also provided around each control valve to permit burner operation meanwhile. At such installations either a permanent flame by-pass is required around the valve in the by-pass line or an additional pressure switch downstream of the zone control valve. The contacts of these low-gas-pressure switches should be wired in series.

Occasionally on new multi-burner equipment, and more frequently on older furnaces and ovens, the temperature is automatically maintained by zone control valves firing "on-off" with a continuous pilot at each burner. When such equipment is shut down, pressure trapped between the closed main safety shut-off valve and closed zone control valves would hold the low-gas-pressure switch closed, keeping the main safety shut-off valve energized so that it could be re-opened even though all burner cocks were not closed.

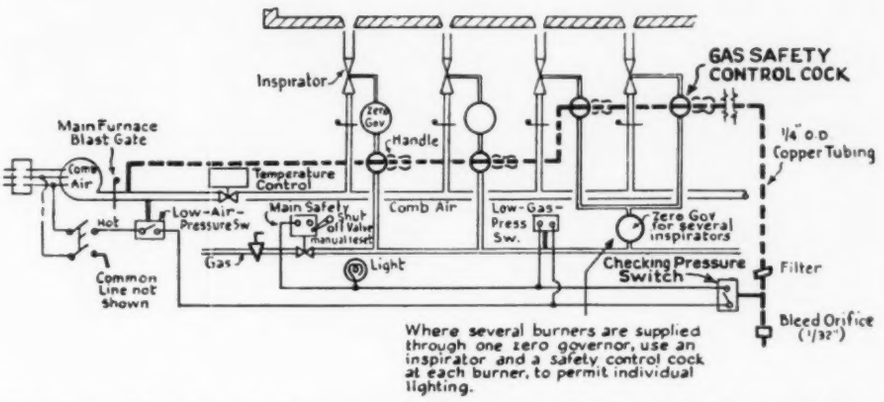


Figure 2 — Where temperature regulation is attained by "high-low" or modulating zone control valves, a shut-off cock is usually provided on each side of control to permit removal for repairs. Valved by-passes permit burner operation to continue.

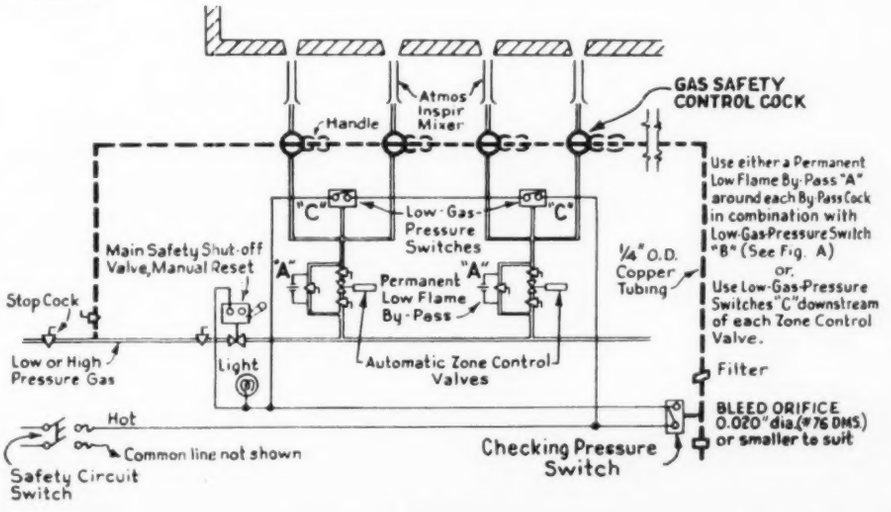
This by-passing of the safety checking system can be prevented by arranging a small solenoid valve to automatically open and bleed pressure from the piping when the main safety shut-off valve is closed. The small solenoid valve is wired to special contacts in the main safety shut-off valve which hold the solenoid valve closed while the shut-off valve is open.

SYSTEM TESTING

The gas safety control system can easily be tested for proper operation while the oven is idle and the burner cocks are closed. The following procedure is suggested:

1. Observe that indicator on main safety shut-off valve reads "Shut."
2. Remove covers from pressure switches and note that all contacts are in the open position.
3. Close safety circuit switch.
4. Open cock and admit gas to the checking line. If air is used, start combustion air blower and open main blast gate.
5. Note that with all gas safety control cocks closed, checking pressure switch closes and light comes on.
6. Open and close any gas safety control cock and observe closing and opening of checking pressure switch.
7. Check for small flow from bleed orifice to make sure it is not obstructed.
8. Try to open manually the main gas safety shut-off valve. Only if all gas safety control cocks are closed, should it be possible to open this valve.
9. Note that contacts of low-gas-pressure switch close as the main gas safety shut-off valve is opened.
10. At the completion of the

Figure 3 — In a combustion air blower system—found most frequently in industrial gas furnace systems—the checking pressure switch is operated by air pressure.


GAS SAFETY CONTROL COCK
Atmos Inspir Mixer
Handle
"C"
Low-Gas-Pressure Switches
Main Safety Shut-off Valve, Manual Reset
"A"
Permanent Low Flame By-Pass
Stop Cock
Low or High Pressure Gas
Light
Automatic Zone Control Valves
1/4" O.D. Copper Tubing
Use either a Permanent Low Flame By-Pass "A" around each By-Pass Cock in combination with Low-Gas-Pressure Switch "B" (See Fig. A) or, Use Low-Gas-Pressure Switches "C" downstream of each Zone Control Valve.
Filter
BLEED ORIFICE 0.020" dia. (#76 DMS) or smaller to suit
Hot
Common line not shown
Safety Circuit Switch
Checking Pressure Switch

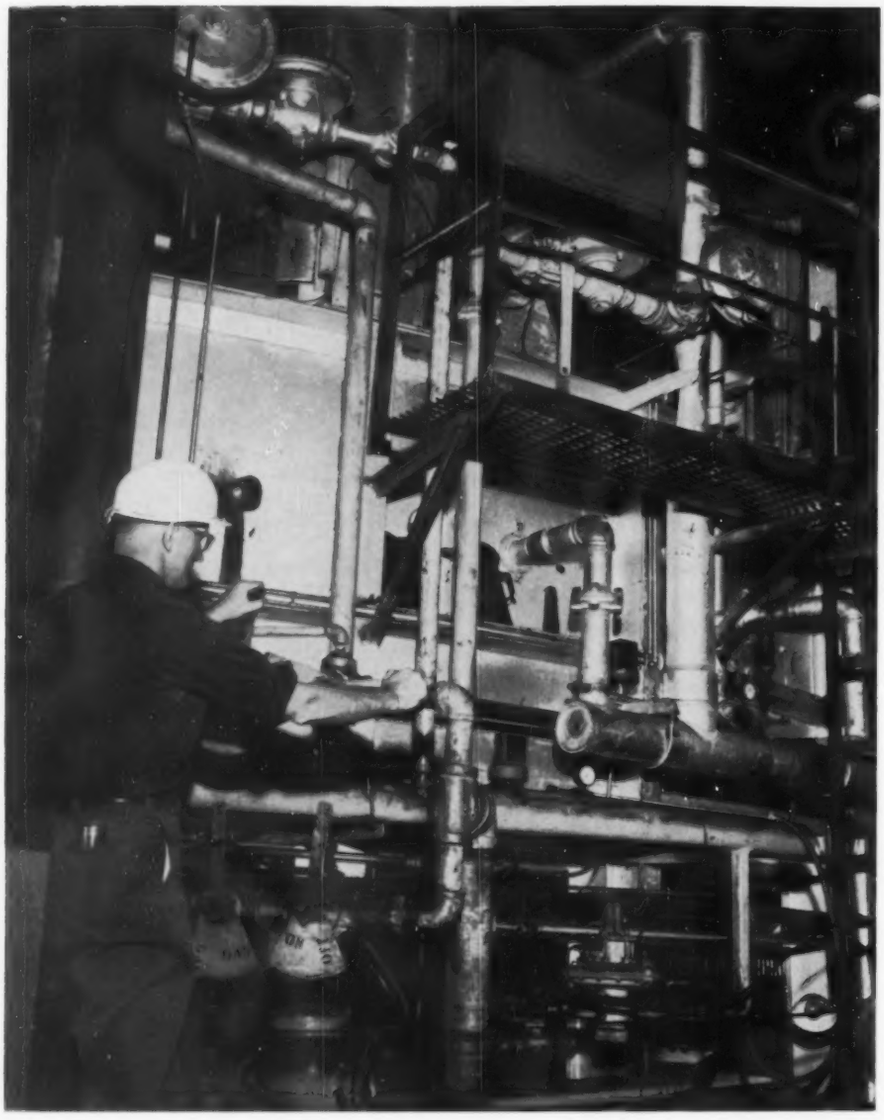


Figure 4 — FM cocks on this furnace insure against premature admission of gas to open burner cocks. In lighting off, gas flows through all cocks by way of side ports and operates the checking pressure switch. If even one cock is slightly opened, the switch cannot operate and the main gas valve cannot be operated.

above tests, all gas cocks would be closed, covers replaced and safety circuit switch left open. The combustion air blower, if any, should be shut down.

If for production reasons the firing of burners cannot be interrupted to shut the oven down for several minutes to make the foregoing tests, the checking pressure switch contacts should at least be inspected to see that they are "open," and the bleed-orifice should be examined externally for obstructions.

The inspector should check the covers of safety control devices (safety shut-off valves, pressure switches, etc.) to make sure they are securely held in place by the screws provided. The presence of valves, etc., with covers removed, or loosely attached with only a screw or two, indicates the possibility of habitual tampering for the purpose of bypassing the safety control arrangement. Where means are furnished, covers of safety shut-off valves should be sealed in place with wire and lead seals, and the condition of the seals checked regularly.

INDIVIDUAL BURNER COCKS

Individual burner cocks should be provided where practical, so that gas can be supplied to the furnace burners one at a time. If the valve arrangement is such that two or more burners must be lighted simultaneously, pilots are necessary. Where fixed pilots are installed, they should be supplied with premixed gas. Zero-governor-inspirator, high-pressure-atmospheric inspirator and gas-mixing-machine type mixers are preferable to low-pressure atmospheric inspirators. The pilot gas should be taken from the upstream side of the safety shut-off valve for the main burners.

A mandatory preventilation purge period, manual or automatic as practical, should be provided. Where possible, the use of limit switches which would require opening doors and fresh-air inlet dampers during the purge period should be employed. The generally accepted purge period is five minutes.

In all cases, a high-caliber, well trained operator is the primary factor in safe lighting-off. In the final analysis, whatever safeguards are provided, safety will depend greatly upon the fireman following the proper lighting procedure.

ELECTRIC FM COCK

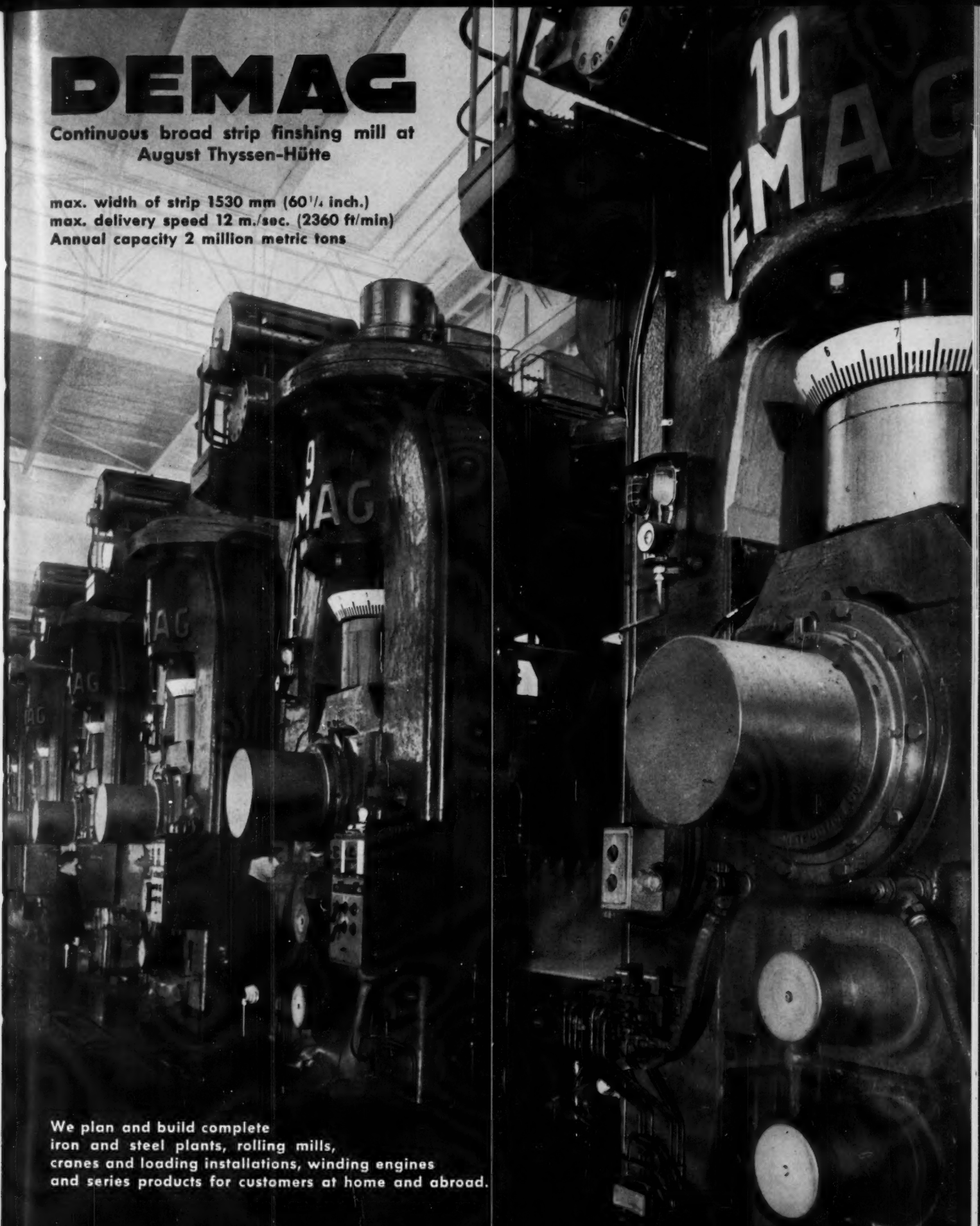
A recent development is the electric FM cock, which consists basically of a conventional 2-way lubricated plug cock equipped with a special supervisory switch assembly arranged so the switch contacts are closed only when the cock is closed. (In sizes from ¾ to 6 in., the only Factory Mutual approved electric FM cock is the Fireye FM Supervisory cock available from Combustion Control Division, Electronics Corporation of America, Cambridge, Mass.) It is similar in application to the pneumatic FM cock and may be used at oil as well as gas burners. The pneumatic FM cock is suitable for use on gas burners only. ▲

Figure 5 — Integral handle shows position of cock which should be fully closed. Gas flows through side ports to operate switch.

DEMAG

Continuous broad strip finshing mill at August Thyssen-Hütte

max. width of strip 1530 mm (60 1/4 inch.)
max. delivery speed 12 m./sec. (2360 ft/min)
Annual capacity 2 million metric tons



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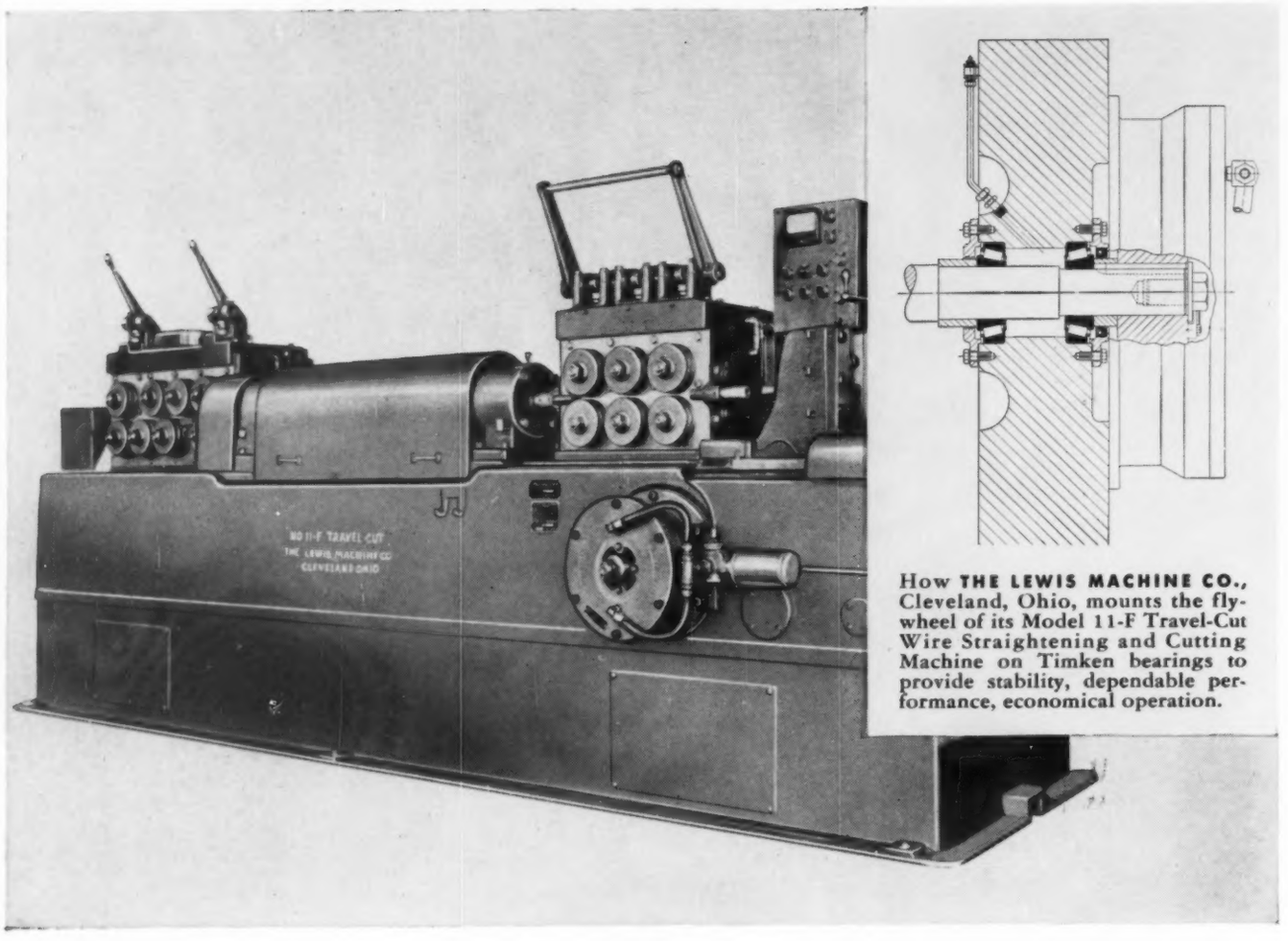

How **THE LEWIS MACHINE CO.**, Cleveland, Ohio, mounts the flywheel of its Model 11-F Travel-Cut Wire Straightening and Cutting Machine on Timken bearings to provide stability, dependable performance, economical operation.

How TIMKEN® bearings keep flywheel stable on automatic wire straightening and cutting machine

TO take the varying loads of automatic wire straightening and cutting, the bearings in this Lewis Model 11-F Travel-Cut have to be extra tough and virtually friction-free. That's why The Lewis Machine Company uses Timken® tapered roller bearings for the flywheel, feed rolls and drive—38 in all. Timken bearings keep the flywheel stable and rotating freely, position gears and feed rolls accurately even under heavy loads.

EXTRA LOAD-CARRYING CAPACITY. Full line contact between their rollers and races gives Timken bearings extra load-carrying capacity. Tapered design lets Timken bearings take *both* radial and thrust loads in any combination. The flywheel doesn't wobble. Gears and feed rolls *stay* in position.

PRACTICALLY FRICTION-FREE PERFORMANCE. Because they're geometrically designed to roll true, and precision-made to live up to their design, Timken bearings virtually eliminate friction. They run smoother, last longer.

NO SHOCK PROBLEMS. Because they're case-carburized, Timken bearings' rollers and races have a hard, wear-resistant surface over a tough, shock-resistant core. They *absorb* shocks, reduce maintenance.

That's why it pays to specify bearings trade-marked "TIMKEN". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ont. Cable: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS ROLL THE LOAD

Date-line Diary...

April 1

Δ The Du Pont Company reduced price of A-1 grade of ductile titanium from $2.25 to $2.05 per lb; A-2 grade from $2.00 to $1.85 per lb.

April 2

Δ Automobile assemblies in March, 1958 totaled 357,049 cars, down 9 per cent from February, 1958 and 38 per cent below March, 1957.
Δ Price of lead in New York was reduced 1¢ to 12¢ per lb.

April 3

Δ The Administration is seeking defense funds totaling $40,700,000,000 for the fiscal year July 1, 1958–June 30, 1959, including an emergency request for an additional $1,600,000,000 which will be primarily spent for top-priority aircraft and missile programs.
Δ The Federal Reserve Board stated that consumers debt in February, 1958 fell $435,000,000; however at the end of February the total debt was $33,300,000,000, an increase of $1,800,000,000 over the year earlier level.

April 4

Δ AISI reported that estimated total employment in the iron and steel industry during February, 1958 was 554,300 which was 21,000 below January, 1958 and 122,000 less than February, 1957. Average hourly payroll cost for February, 1958 amounted to $3.088, compared with $3.042 in January, 1958 and $2.852 in February, 1957. Total payroll for February amounted to $261,725,000 compared with $297,612,000 in January; hours worked a week in February 34.2 compared with 35.1 in January.
Δ Barium Steel Corp. shareholders will be asked to approve a 1-for-4 reverse split of capital shares and a reduction in authorized capitalization from 10,000,000 shares of $1 par value to 2,500,000 shares of $4 par value.
Δ Phoenix-Rheinrohr A.G. of Duesseldorf, West Germany, report sales for the fiscal year 1956/57 amounting to $387,857,143, compared with $333,800,000 for 1955/56 fiscal year. Net profit distributed as cash dividend (for each year) equalled $4,435,000 or $2.14 per share.

April 7

Δ The Labor Dept. reported that unemployment compensation claims for the week ended March 22 totaled 3,278,000, a rise of 14,700 from the previous week; in the week ended March 29, 421,900 new claims were filed, exceeding the new claims for the previous week by 17,500.
Δ The Commerce and Labor Depts. reported construction outlays in the quarter ended March 31 totaled $9,700,000,000 a $200,000,000 increase over the same period of 1957.
Δ The AISI reports that the operating rate of the steel industry for the week of April 7 is scheduled at 1,306,000 tons. This compares with 1,312,000 tons one week ago (48.6 per cent capacity) and 2,310,000 tons one year ago. Index of production for the week is 81.3.
Δ The Bureau of Mines reports estimated production of Pennsylvania anthracite for the month of March, 1958 totaled 1,492,000 tons, compared with 1,782,000 in February 1958 and 1,807,000 in March, 1957.
Δ The AISI reports shipments of finished steel products for February, 1958 totaled 4,262,935 net tons compared with 5,215,417 tons shipped in January and 7,066,732 tons during February, 1957.

April 8

Δ Republic Steel Corp., Gadsden, Ala., plant relighted four open hearth furnaces, and anticipates resumption of operations of its large diameter pipemill next week, it will recall 500 to 600 laid-off workers.

April 9

Δ The Aluminum Assn. reported that shipments of aluminum sheet and plate in February, 1958 totaled 84,769,000 lb, compared with 88,251,000 lb in January, 1958; shipments of aluminum foil in February, 1958 amounted to 13,833,922 lb, compared with 17,252,615 lb in January, 1958.
Δ Price of copper was reduced by custom smelters ½¢ to 23½¢ per lb.

April 10

Δ The Edison Electric Institute reported that electricity output in the week ended April 5, fell 3.1 per cent below the 1957 like period, the largest percentage decline in almost 12 years.
Δ Shipments of iron and steel castings for 1957 amounted to 15,240,000 short tons compared with 16,744,000 short tons in 1956.
Δ The AISI reports total production of ingots and steel for castings during March amounted to 6,254,000 net tons compared with 5,782,323 during February, 1958 and 10,589,074 tons in March, 1957; for the first quarter, 1958 production amounted to 18,790,235 tons compared with 25,010,921 tons in the fourth quarter, and 31,585,042 tons in the first quarter of 1957.

April 14

Δ The AISI reports that the operating rate of the steel industry for the week of April 14 is scheduled at 1,283,000 tons. This compares with 1,308,000 tons (48.5 per cent of capacity) one week ago and 2,313,000 tons one year ago. Index of production for the week is 79.9.
Δ The U.S. Dept. of the Interior, Bureau of Mines, reports that marketed production of natural gas for the year 1957 amounted to 10,629,200,000,000 cu ft, 5 per cent above the 1956 marketed production; production for the fourth quarter of 1957 amounted to 2,762,100,000,000 cu ft, six per cent above the same quarter of 1956.

April 16

Δ Private home building starts in March amounted to an 880,000 yearly pace, slightly below February and the lowest rate since early 1949.
Δ Stockholders of The National Supply Co. have approved the proposed merger of the company into Armco Steel Corp., Armco stockholders are to vote on the proposal at their annual meeting tomorrow.

April 17

Δ President Eisenhower signed the $1,800,000,000 highway construction bill despite "serious misgivings" expressing that he regarded as "grave defects" its provisions increasing the government's share of road-building costs, but approved the bill in the hope of increasing employment.
Δ Marriner S. Eccles, former chairman of the Federal Reserve Board, advocated tax reductions amounting to $7,000,000,000, reporting to the Senate Finance Committee that the recession is becoming increasingly severe, and may get even worse unless tax relief is provided promptly.
Δ The ARCI reports that deliveries of new domestic freight cars in March, 1958 totaled 5,906 compared with 5,316 in February, 1958 and 9,772 in March, 1957. Orders totaled 239 compared with 294 in February and 3,349 in March, 1957. Backlog of cars on order as of April 1 stood at 38,027 compared with 43,750 a month earlier and 107,708 on April 1, 1957.
Δ The Bureau of Mines, U.S. Department of the Interior, reported that production of iron ore in the United States for January, 1958 totaled 3,375,000 long tons; shipments 1,455,000 long tons; imports amounted to 1,785,210 long tons; exports 36,840 long tons.
Δ The Bureau of Mines reported that the consumption of scrap during February, 1958 totaled 3,527,000 gross tons, pig iron used was 3,631,000 gross tons; this compares with 4,072,071 tons of scrap and 4,208,692 tons of pig iron in January, 1958.
Δ Federal Reserve Board approved a reduction in the discount rate of five regional Federal Reserve Banks from 2¼ per cent to 1¾ per cent.
Δ Kennecott Copper Corp. cut its copper output an additional 3,350 tons monthly, resulting in reducing its production to 67 per cent of its 1957 rate.
Δ Crude oil production permissible in Texas in May was set at 2,394,537 bbl daily, down 42,537 bbl from present permissible output.

April 18

Δ Stockholders of Armco Steel Corp., approved the merger of National Supply Corp., at their annual meeting today. Similar approval has been granted the merger by the stockholders of the National Supply Corp.

April 19

Δ The Aluminum Assn. reported primary aluminum production in the United States during March, 1958, was 137,916 short tons compared with 125,602 short tons in February, 1958 and 135,706 tons in March, 1957.

April 21

Δ The AISI reports that the operating rate of the steel industry for the week of April 21 is scheduled at 1,265,000 tons. This compares with 1,285,000 tons (47.6 per cent capacity) one week ago and 2,269,000 tons one year ago. Index of production for the week is 78.7.
Δ Secretary of Treasury Anderson estimates deficits of $3,000,000,000 for fiscal 1958 and $8,000,000,000 to $10,000,000 for 1958–59 due to mounting anti-recession and defense expenditures. He stated that the treasury may have to seek an increase in the present Federal debt ceiling of $280,000,000,000.
Δ The Labor Dept. reported that number of persons drawing unemployment compensation for the week ended April 5, amounted to 3,314,307, an increase of 37,802 over the previous week.
Δ Industrial Heating Equipment Assn. reports that new orders for industrial furnaces in March, 1958, were $2,871,000, compared with $9,090,000 in March, 1957; orders for induction and dielectric heating equipment in March, 1958 were $374,000 compared with $784,000 in March, 1957.

April 22

Δ Ford Motor Company reported sales for the first quarter of 1958 totaled $1,095,800,000, down $473,000,000 from the same 1957 period; net income fell to 42¢ a share compared with $1.85 in 1957.
Δ Harold J. Ruttenberg, former research director of United Steelworkers, has appealed to David J. McDonald, Steelworkers' president, and Roger M. Blough, U.S. Steel chairman, to agree on a freeze of steel wages and prices for one year and two years respectively as an essential move to "pull the steel industry out of the depression."

April 23

Δ Machine tool orders for March were up 28 per cent over February, 1958, and totaled $29,100,000.
Δ Steel scrap prices fell $2 to $3 a ton in major steel-making centers. In Pittsburgh, No. 1 heavy melting scrap declined $3, selling at $32 a ton.
Δ Jessop Steel Co. reports net income for the year 1957 of $1,061,980, or 1.86 per share; compared with net income of $1,529,505 or $3.09 per share in 1956.

April 24

Δ Edison Electric Institute reported that electricity production in the week ended April 19 totaled 11,107,000,000 kwhr compared with 11,307,000,000 the week previous, and 11,485,000,000 for the year earlier period.
Δ The Bureau of Labor Statistics reported that living costs rose to 123.3 per cent of the 1947–49 average, 7 per cent above the February level.
Δ Youngstown Sheet and Tube Co. announced it will start another steelmaking furnace at the Campbell Works, which will make a total of six in operation.

April 25

Δ Price of copper was raised ¼¢ by custom smelters to 23-¾¢ a lb.
Δ Titanium Metals Corp. of America announced a new series of titanium mill product price reductions; overall base prices have been lowered by more than 10 per cent, with some products such as high-strength alloy plate and billet, being lowered by 20 to 30 per cent.

Δ General Electric Co. sales for the first quarter of 1958 were reported to be $964,966,000, earnings were $49,184,000 equal to 56¢ per share; for the first quarter of 1957 sales amounted to $1,048,850,000, earnings $64,006,000, or 73¢ a share.

Δ Shipments of iron and steel castings during February 1958 amounted to 911,352 short tons compared with 1,051,711 tons in January, 1958 and 1,336,078 tons in February, 1957.

Δ The suit filed by Williams Engineering Co. vs The Babcock & Wilcox Company and Republic Steel Corp. to restore an agreement in connection with the development of continuous steel-casting equipment was decided in favor of the defendants. Judge Joseph P. Willson, United States District Court for the Western District of Pennsylvania ruled that the defendants had "acted honestly and in good faith in the attempt to successfully develop the process" and further that the facts "show no injustice whatsoever to Williams on the issue of termination."

Δ The AISC reports that bookings of fabricated steel in March totaled 195,970 tons compared with 185,646 tons in February, 1958 and 318,935 tons in March 1957; shipments in March, 1958 amounted to 336,598 tons compared with 282,576 tons in February, 1958 and 342,451 tons in March, 1957.

Δ The Aluminum Assn., reported that shipments of aluminum sheet and plate in March, 1958 totaled 92,153,000 lb compared with 84,769,000 lb in February, 1958; shipments of aluminum foil in March, 1958 amounted to 15,246,341 lb compared with 14,217,900 lb in February, 1958.

April 28

Δ The AISI reports that the operating rate of the steel industry for the week of April 28 is scheduled at 1,293,000 tons. This compared with 1,270,000 tons one week ago (47.1 per cent capacity) and 2,226,000 tons one year ago. Index of production for the week is 80.5.

April 30

Δ Commerce Secretary Weeks reported that total employment as of April 15 amounted to 62,900,000, up 600,000 over mid-March; unemployment at mid-April stood at 5,100,000, down 78,000 from a month earlier.

Δ General Motors Corp. reported first quarter, 1958 sales of $2,721,373,342, net income 184,601,266 or $0.65 per share, compared with sales of $3,076,974,000, income of $261,357,742 or $0.93 per share in the first quarter of 1957.

Δ Chrysler Corp. sales for the first quarter 1958 amounted to $537,000,000, sustaining a loss of $15,100,000; in the same period of 1957 sales were $1,100,000,000, profit $46,500,000 or $5.34 per share.

Δ F. W. Dodge Corp. reports that contracts for future construction in the United States in March 1958 totaled $2,721,228,000, down 12 per cent from March, 1957; the cumulative total of contracts for the first quarter of 1958 amounted to $6,721,767,000 down 11 per cent from the same period in 1957.

Δ The merger of Armco Steel Corporation and The National Supply Company being approved by stockholders of both parties becomes effective May 1, 1958.

Δ Westinghouse Electric Corp. reports for the first quarter of 1958 sales amounting to $449,329,000, net income $12,903,000 equal to 73¢ per share; for 1957, same period, sales were $475,686,000, net income $14,198,000 equal to 82¢ per share.

STEEL COMPANIES QUARTERLY FINANCIAL REPORTS—ENDING MARCH 31, 1958

	1958 Net income	1958 Net profit	1958 Earnings per share	1957 Net income	1957 Net profit	1957 Earnings per share
Acme Steel Co.	$ 28,535,962	$ 439,827	$ 0.16	$ 44,213,939	$ 2,234,451	$ 0.94
Alan Wood Steel Co.	12,500,000	33,000	....	18,530,000	899,000	....
Allegheny Ludlum Steel Corp. Ltd.	50,454,925	725,900	0.19	81,294,626	4,790,665	1.25
Armco Steel Corp.	142,958,810	9,171,693	0.75	198,205,419	15,487,752	1.29
Barium Steel Corp.	9,350,000	(422,700)	....	33,960,484	2,058,055	0.51
Bethlehem Steel Corp.	497,559,327	24,819,490	0.52	676,107,988	53,427,655	1.16
*A. M. Byers Company	5,302,487	37,050	....	....	....	....
Carpenter Steel Co.	....	604,858	....	....	2,065,495	....
Colorado Fuel and Iron Corp.	....	(1,390,096)	(0.45)	....	4,552,392	1.30
Continental Steel Corp.	9,255,848	580,839	1.12	11,121,959	662,262	1.28
Copperweld Steel Co.	20,817,309	(112,505)	(0.14)	34,702,273	988,994	0.89
Crucible Steel Co. of America	44,610,060	172,395	0.05	70,598,795	3,372,606	0.93
Detroit Steel Corp.	13,000,000	(300,000)	(0.12)	24,600,000	1,008,166	0.31
Eastern Stainless Steel Corp.	9,728,255	249,001	0.35	14,041,169	661,421	0.92
Firth Sterling, Inc.	3,662,200	(281,600)	....	8,510,500	398,000	0.34
Granite City Steel Corp.	28,902,709	2,055,182	0.95	33,695,881	3,421,451	1.60
Inland Steel Co.	150,277,286	7,961,147	1.40	203,649,640	14,613,704	2.59
Interlake Iron Corp.	19,497,198	717,716	0.32	30,036,458	1,725,987	0.77
Jessop Steel Co.	4,631,077	153,160	0.27	7,918,099	544,886	0.96
Jones & Laughlin Steel Corp.	144,584,000	1,657,000	0.17	203,965,000	12,823,000	1.89
Kaiser Steel Corp.	46,245,288	1,734,426	0.36	54,925,630	7,784,118	2.22
Keystone Steel & Wire Co.	....	1,277,010	0.68	30,572,113	2,066,798	1.10
Lone Star Steel Co.	10,249,199	482,638	0.17	25,738,467	3,288,951	1.25
Lukens Steel Co.	24,631,807	1,470,230	1.54	32,405,892	3,365,498	3.53
McLouth Steel Corp.	....	454,037	0.27	....	3,431,813	0.67
National Steel Corp.	113,488,782	3,801,426	0.51	176,858,209	13,501,506	1.82
National Supply Co.	48,771,620	518,649	0.18	76,135,384	4,223,969	1.44
Pittsburgh Coke & Chemical Co.	10,265,000	210,000	0.09	13,681,000	908,000	0.70
Pittsburgh Steel Co.	32,112,512	(968,881)	....	49,786,939	2,011,260	1.06
Republic Steel Corp.	190,635,879	8,583,506	0.55	354,406,193	28,052,826	1.81
Sharon Steel Corp.	23,901,809	(283,213)	....	47,655,789	1,592,644	1.45
United States Steel Corp.	800,074,024	62,426,679	1.04	1,166,484,088	115,478,109	2.03
*Washington Steel Corp.	....	(89,505)*	....	....	1,083,547*	1.79*
Wheeling Steel Corp.	46,525,000	505,000	0.03	71,747,000	4,559,000	2.12
Youngstown Sheet and Tube Co.	115,338,971	3,576,100	1.04	192,075,871	10,607,267	3.09

* 6 months report. Numbers in parentheses indicate losses.

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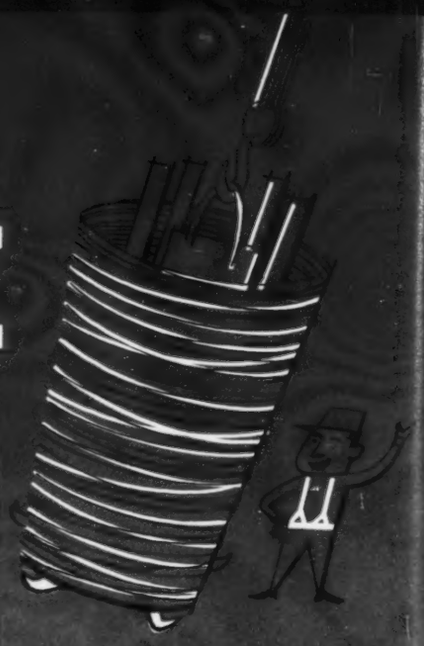

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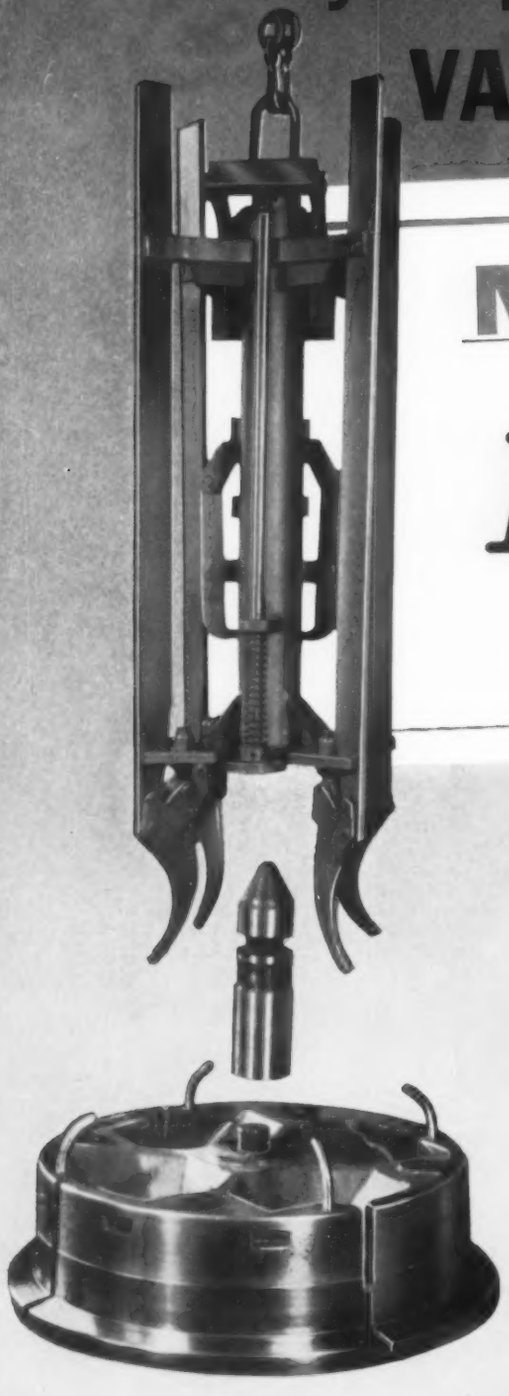

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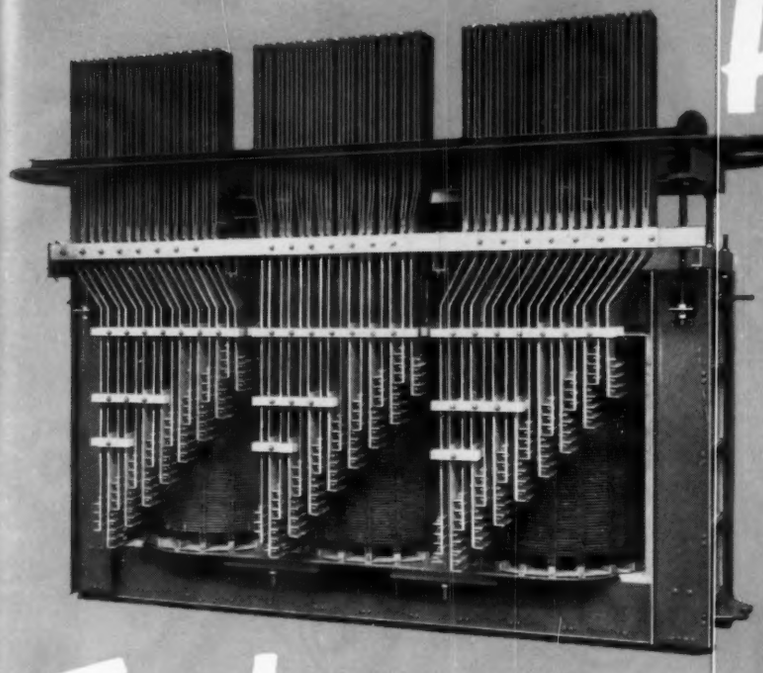
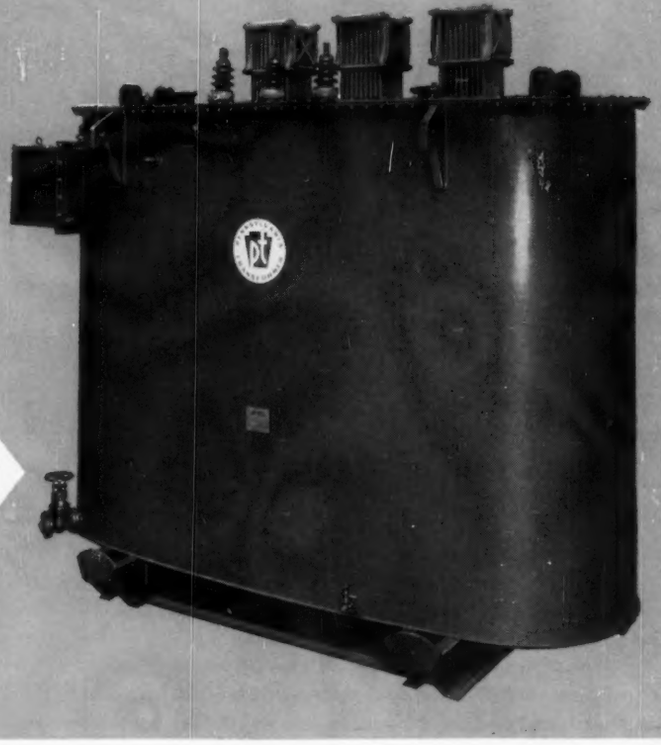


High Current?

The 82,000-ampere low voltage line current for which this Pennsylvania Furnace Transformer is designed is one of the highest current ratings ever provided for a furnace transformer in this country. The transformer is rated at 16,000/21,300 kva. High voltage: 13,200△ volts. Low voltage: 250△ volts with a full-capacity tap range in 10-volt steps down to 150 volts.

Fast Delivery?



Only 20 calendar days were required to build and ship this 25,000-kva Pennsylvania Furnace Transformer. Even the *promised* shipping period of four weeks had looked like excellent service to the West Coast steelmaker—and by cutting this time by one-fourth, Pennsylvania saved the customer several days of costly downtime for the electric furnace involved. High voltage: 6,600 volts. Low voltage: 450 to 300 volts.

OF COURSE . . . it takes a lot of "everyday" know-how to accomplish the unusual with furnace transformers. Pennsylvania has established a nation-wide reputation for tackling and solving the most difficult problems in this highly demanding field . . . and not-so-incidentally, has designed and built virtually every size and type of furnace transformer now in use: from 250 through 25,000 kva, and from 3175 through 82,000 amperes. To put this furnace transformer experience to work for you, contact Pennsylvania Transformer Division, McGraw-Edison Company, Box 330, Canonsburg, Pa.

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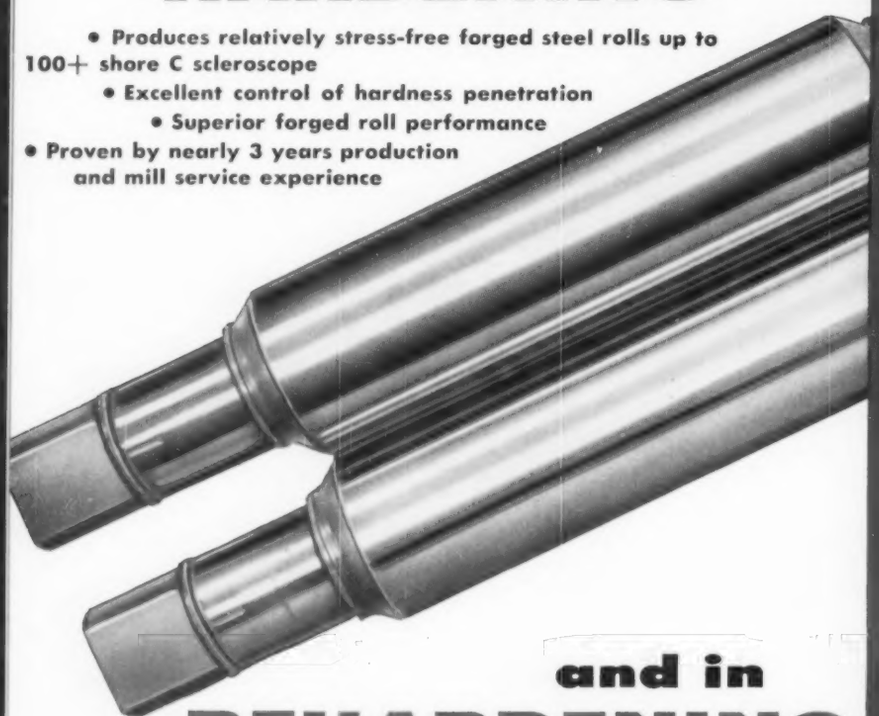
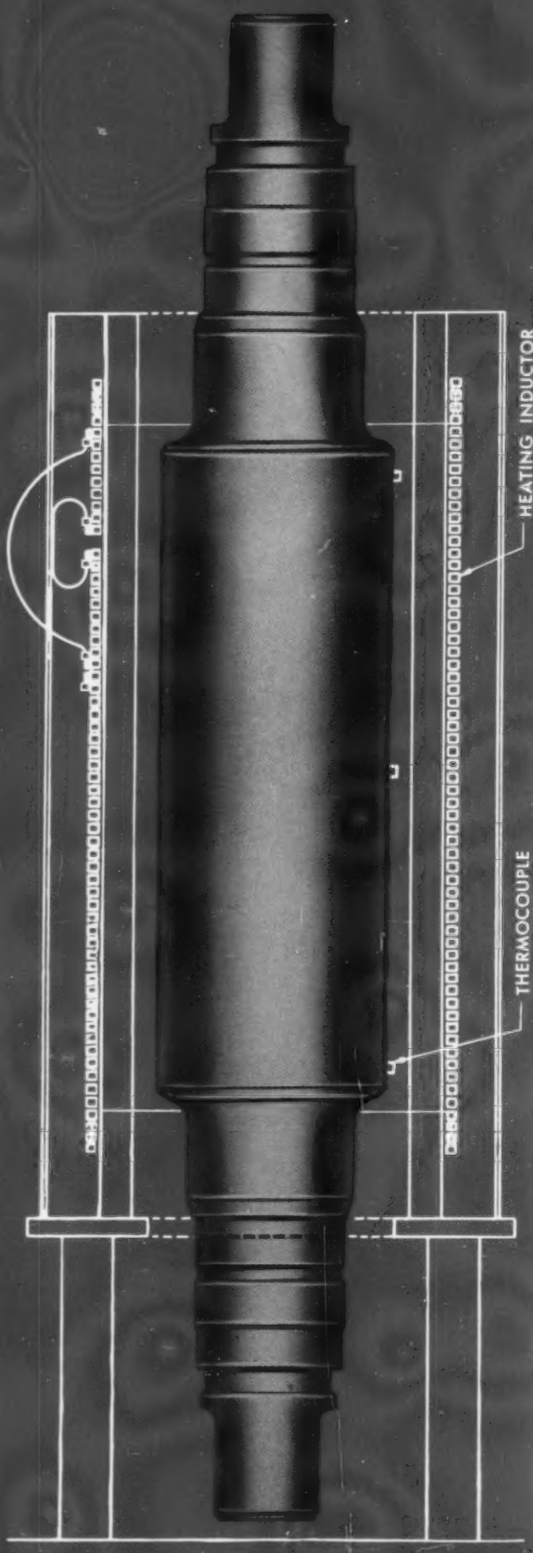
With progressive INDUCTION HARDENING

- Produces relatively stress-free forged steel rolls up to 100+ shore C scleroscope
- Excellent control of hardness penetration
- Superior forged roll performance
- Proven by nearly 3 years production and mill service experience





and in REHARDENING and REMAKING too

- Induction heating process removes original surface hardening and stresses
- Prevents distortion of the journals
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- Roll is rehardened by progressive induction hardening and returned to mill with no change in the close tolerance dimensions of the journals

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Ohio Iron and Steel Rolls: Carbon Steel Rolls—Ohioloy Rolls—Ohioloy "K" Rolls—Flintuff Rolls—Double-Pour Rolls—Chilled Iron Rolls—Denso Iron Rolls—Nickel Grain Rolls—Nioloy Rolls—Special Iron Rolls—Forged Steel Rolls

Industry News...

ALLIS-CHALMERS EQUIPS NEW KAISER STRIP MILL

△ A new 86-in. hot strip mill roughing train at Kaiser Steel Corp.'s Fontana, Calif., plant is equipped with Allis-Chalmers motors, m-g sets, controls and switchgear. Construction of the hot strip mill is part of a major expansion program that will eventually double Kaiser Steel's capacity. Completion of the installation of Allis-Chalmers equipment at the expansion site is scheduled for mid-June.

Roughing train driving equipment includes a 3000-hp, 150 rpm synchronous motor for the scale breaker; a 5000-hp, 514-rpm wound rotor motor for the broadside stand; a 6000-hp, 240-rpm synchronous motor for roughing stand No. 2; and three 6000-hp, 360-rpm synchronous motors for No. 3, 4 and 5 roughing stands. The synchronous machines are rated at 80 per cent power factor. In addition, three 1500-hp squirrel cage descaling pump motors with 2300-volt Type H starters are supplied.

Power for an electrical inching and dynamic braking system for all six stands of the main mill will be furnished by an m-g set consisting of three 45-kw d-c generators driven by a 75-hp squirrel-cage motor.

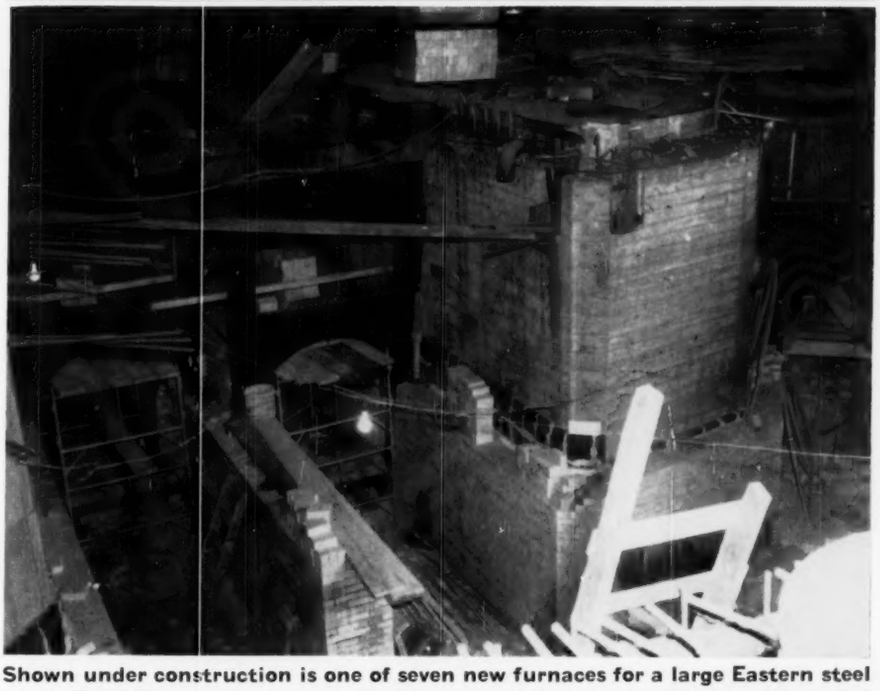
Altogether, 13 starting and isolating breakers for this roughing train—the complete lineup of high voltage switchgear for tieing into Kaiser's 6600-volt system—were ordered from Allis-Chalmers Manufacturing Co.

Edger and slab squeezer auxiliary mill motors receive power from a seven unit m-g set driven by a 2000-hp synchronous motor. This piece of equipment rated at 1600 kw, is now installed. Variable voltage control is used in this circuitry.

Control and a 600-kw supporting m-g set, consisting of three 200-kw units with a 1000-hp drive motor, serve as the power supply for the 177 3-hp d-c delay table and rougher number 5 approach table motors. The 200-kw generators are controlled by variable voltage control panels featuring magnetic amplifiers. The run-out table motors are controlled by individual protection panels placed in control center type cubicles.

Control desks and operators' stations, which control over-all mill operation, have been furnished completely by Allis-Chalmers for this mill.

NEW OPEN HEARTHS FEATURE JUMBO VALVES



Shown under construction is one of seven new furnaces for a large Eastern steel plant. The 350-ton open hearths require some of the largest valves ever fabricated by Blaw-Knox Co. On the left are two double deck reversing valves, which have 6 x 8-ft openings. On the right is a stack valve having a 9 x 10-ft opening. Following the trend for increased open hearth capacity, the furnaces will be equipped with seven doors, rather than five. In addition to the water cooled valves and dampers, doors and frames and two new 500 cu ft capacity dolomite machines will be furnished.

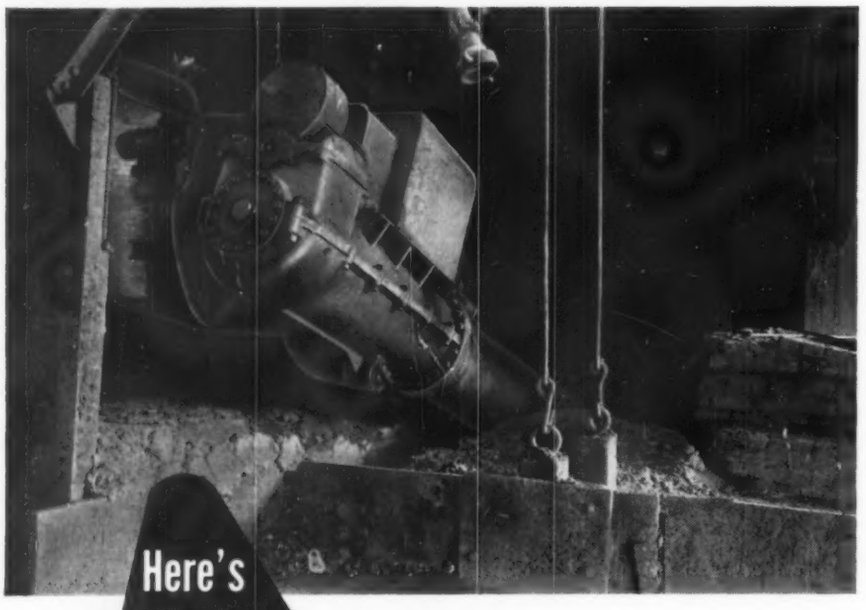
LUKENS OXYGEN PLANT TO BE BUILT BY LINDE

△ The oxygen supply system now being used at Lukens Steel Co., Coatesville, Pa., will be revised utilizing an automatically operated on-site plant, capable of producing high-purity gaseous oxygen at a maximum rate of at least 80,000,000 cu ft a month.

Scheduled to go on-stream early in January of 1959, this single on-site source of supply will replace a Linde 20,000,000 cu ft plant, plus the supplemental liquid deliveries now meeting Lukens' oxygen needs. Linde will design the unit, provide the capital for its construction, and operate and maintain the plant when it goes into production.

Although the new oxygen plant is designed for automatic, unattended operation, a Linde plant superintendent will be permanently assigned to the unit, making regular inspections and overseeing maintenance. But, through the use of a unique control system, the plant will automatically produce oxygen at a rate required by the steel mill's operations, pump oxygen into storage tanks for backup requirements and regulate the operation of numerous valves, switches, motors, meters, and so forth. An electronic monitoring system, reporting continuously to a central office, will keep track of the operation of important components to aid in the advance detection of possible trouble. If the monitoring system

180 Bailey
CLAY GUNS
IN CONTINUOUS SERVICE



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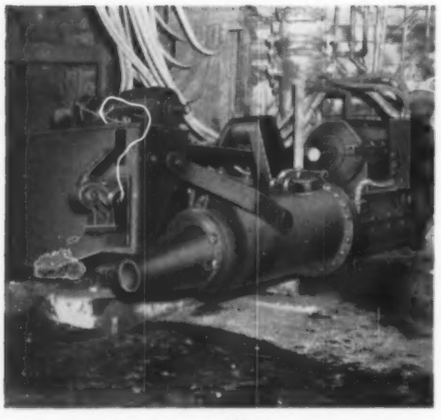
- Exceptional Power
- Accurately Controlled
- Operated by Three Separate Motors



With clay pressures of 600 psi, these guns provide ample power for plugging and maintaining long tapping holes. A unique mounting and operating system assures fast and accurate positioning with the ultimate in safety.

Bailey Electric Plunger Clay Guns are adaptable to both blast furnaces and large electric furnaces.

Write for Bulletin

WILLIAM M. Bailey COMPANY
ENGINEERS
LEADERSHIP THROUGH QUALITY
1221 BANKSVILLE ROAD PITTSBURGH 16, PA

gets warning of trouble ahead, a Linde supervisor will be notified as soon as possible so that the condition can be corrected without curtailment of operations.

In addition to the producing plant, facilities will be erected for storing oxygen as a gas and as a liquid. Both storage facilities will be an integral part of the supply system, although only the gas receivers will be filled by side stream production of the on-site plant. Liquid oxygen in the standby storage tank will automatically be converted to a gas and piped to use points in the steel mill if the on-site plant is down for any reason.

AWARDS PLATE MILL CONTRACT TO MESTA

△ Mesta Machine Co. has been awarded a contract covering the design and manufacture of a 140 in. four-high plate mill, with vertical edging mill and auxiliary equipment including transfer cars, tables, and descaling and lubricating systems. The installation will be made at the Coatesville, Pa., plant of Lukens Steel Co.

The arrangement of this plate mill is unusual since the unit may operate as a roughing mill for rolling ingots up to a maximum of 80 in. x 30 in. x 100 in. and reducing them into breakdowns for further processing on existing plate mills, or it can complete the rolling of plates to finished size directly. The vertical edging mill, placed in tandem with the four-high mill, is the largest ever used with a plate mill in this country, and provides the edge rolling of the ingot, which remains in the horizontal position during the complete operation. When operating as a plate mill, the new four-high mill can produce carbon and stainless steel, and other alloy plate mill products up to 130 in. wide.

DRAVO TO BUILD THIRD McLOUTH ORE BRIDGE

△ A third man trolley ore bridge will be built for McLouth Steel Corp.'s Trenton Works.

The new bridge will be identical to the two now in use. It will unload approximately 1050 gross tons an hour from the boats to the stockpile. The bridges also reclaim ore and limestone from this stockpile to feed the blast furnaces.

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Increases Production by 200-300% or Better

We have developed a new basic type cold draw bar bench.

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- **NO CARRIAGE**
- **NO SCRAP ENDS**
- **HIGHER SPEEDS—BEFORE CHATTERING EFFECT**
- **NO MAXIMUM LIMIT TO LENGTH OF DRAWN BARS**

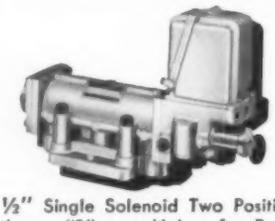
We need a steel plant to install and operate this draw bench. This is an excellent opportunity to receive an ultra-modern cold draw bar bench at very low cost.

MIELE ENGINEERING SERVICE
220 E. MARKET ST.
WARREN, OHIO

- ***Designers of Special Steel Mill Equipment***
- ***Construction Drawings***
- ***Revamp work our specialty***

Get more production—at lower cost with

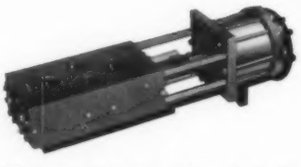
Quick-As-Wink®
AIR AND HYDRAULIC
Control Valves



½" Single Solenoid Two Position 4-way "B"-type Valve, for Pressures up to 250 psi.

¼" 4-way Cam Operated Spring Return Valve, for Pressures up to 125 psi.

½" 2 Pedal Foot Operated 4-way Valve, for Pressures up to 200 psi.

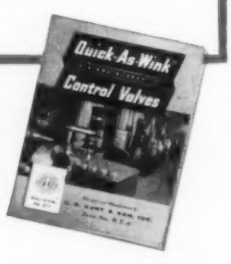


1" Pilot Cylinder Operated 4-way Two Position Hydraulic Valve, for Pressures up to 5000 psi.

Cut your costs—and increase your production—by installing Quick-As-Wink Control Valves **throughout your plant.** Proven in service, our exclusive, patented* construction assures year after year of long, efficient, dependable **and low cost operation.** Production and maintenance men know Quick-As-Wink Valves are unsurpassed. Can you afford to gamble with less? Hundreds of different types, actions and sizes from ¼" to 4". Get full details.

*U. S. Patent No. 2,645,450

Write for **BULLETIN NO. 571** *Today.*



Quick-As-Wink®
AIR AND HYDRAULIC
Control Valves

***Mfd. by* C. B. HUNT & SON, INC., 1923 East Pershing St., Salem, Ohio**

— Engineering and Sales Representatives in the Principal Cities —

Over-all, the bridge will be 545 ft long, with a 350-ft span between the v-shaped pier leg and the shear leg. At the pier end, a hinged apron extends 120 ft over the river to accommodate the largest ore boats. The shear leg and cantilever of the bridge extend 75 ft to permit unloading into ore transfer cars which shuttle back and forth to the blast furnaces.

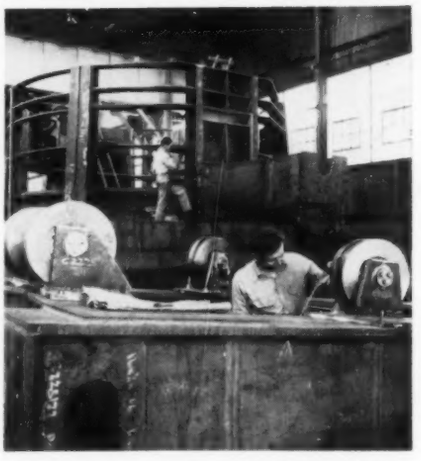
Legs, trucks, trolley and equipment houses of the bridge will be of welded steel construction.

A ring-type turntable on the man trolley will permit rotation of the bucket in either direction for more efficient unloading and cleanup of ore from lake boats.

Bucket hoisting speed is 300 fpm, and the trolley will rack back and forth at 985 fpm. Normal travel speed of the bridge is 90 fpm. With a recent 423-ft addition to the ore storage yard, the tracks on which the three bridges will operate will be 1200 ft long.

Protecting the structure from wind damage will be Dravo spring-set, rail clamps, designed to hold the bridge stationary in winds up

DUQUESNE FURNACE



Taking shape at the Ambridge Plant of U. S. Steel Corp.'s American Bridge Division is a new electric-arc furnace for the corporation's Duquesne Works. Destined to increase Duquesne Works' electric furnace steelmaking capacity by 75,000 tons per year, the furnace will be shipped from Ambridge to Duquesne after shop assembly of all parts. With a hearth 20 ft in diam, the furnace will have a rated capacity of 83 tons per heat. The Duquesne Works' electric furnace shop currently is being expanded to accommodate the new furnace.

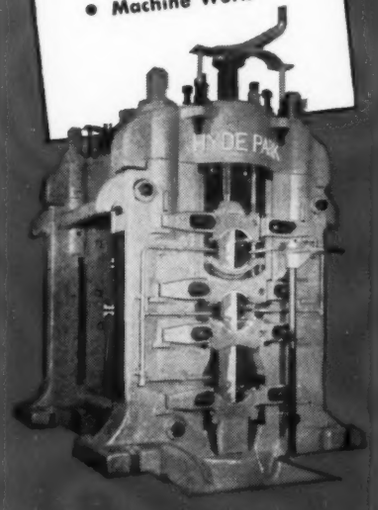
RED CIRCLE Rolls ALLOY-CHILLED

Hyde Park

Rolling Mill Equipment

For more than 50 years Hyde Park Steel Mill equipment has been helping American industry lead the world — equipment such as—

- Bar Mills
- Merchant Mills
- Sheet and Strip Mills
- Pinion Stands
- Roller Tables
- Reduction Drives
- Stretcher Levellers
- Guillotine Shears
- Sheet Mill Shears
- Roll Lathes
- Special Machinery
- Machine Work



For finer finish, long life and greater tonnage, specify Red Circle Rolls.

Hyde Park

FOUNDRY & MACHINE CO.

Hyde Park, Westmoreland Co., Pa.

ROLLS

ROLLING MILL MACHINERY

GRAY IRON CASTINGS

to 105 mphr. The clamps engage automatically when wind velocity reaches 35 mphr or power is shut off.

The bridge will operate on a 2300-volt, three-phase, 60-cycle a-c power supply, with adjustable voltage control. A motor-generator unit in the equipment house at the top of the span produces the necessary d-c voltages for a total of 17 different motors, ranging in size from 33 hp to 325 hp.

ALLIANCE MACHINE ADDS WEST COAST OFFICE

△ The Alliance Machine Co. recently opened an engineering office on the West Coast. To enable them to give better service they have organized a Western Division with offices at 550 Kearny St., San Francisco 8, Calif.

BORG-WARNER CHANGES CRANE DIVISION NAME

△ The Industrial Crane & Hoist operation of Borg-Warner Corp.'s Ingersoll Products Division has been renamed Borg-Warner Industrial Cranes.

J. H. Ingersoll, president of the division said the change was made to identify Borg-Warner more closely with the materials handling business.

Industrial Cranes designs and fabricates a complete line of cranes, ranging from the lightest capacity jib and portable gantry cranes to heavy duty overhead models.

Industrial Cranes is expanding the scope of its operations to include a more complete line of related materials handling equipment.

REFRACTORIES PLANT SERVES CHICAGO AREA

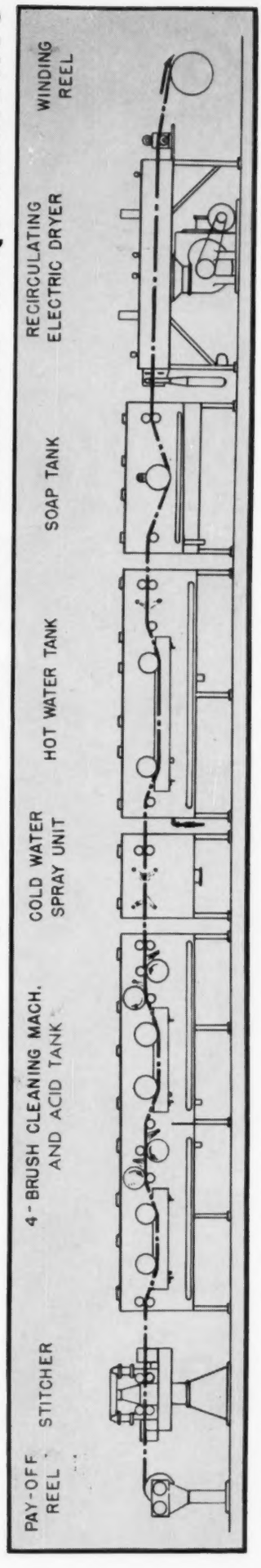
△ The latest Harbison-Walker Refractories Co. addition to refractory production capacity is a modern efficient plant for the manufacture of basic refractories at Hammond, Ind.

The plant uses chrome from overseas, nodularized dead-burned magnesite from the new Ludington, Mich., facility, and other basic raw materials.

The plant site, in addition to satisfying the steel production needs, has many other desirable features.

(*Please turn to page 164*)

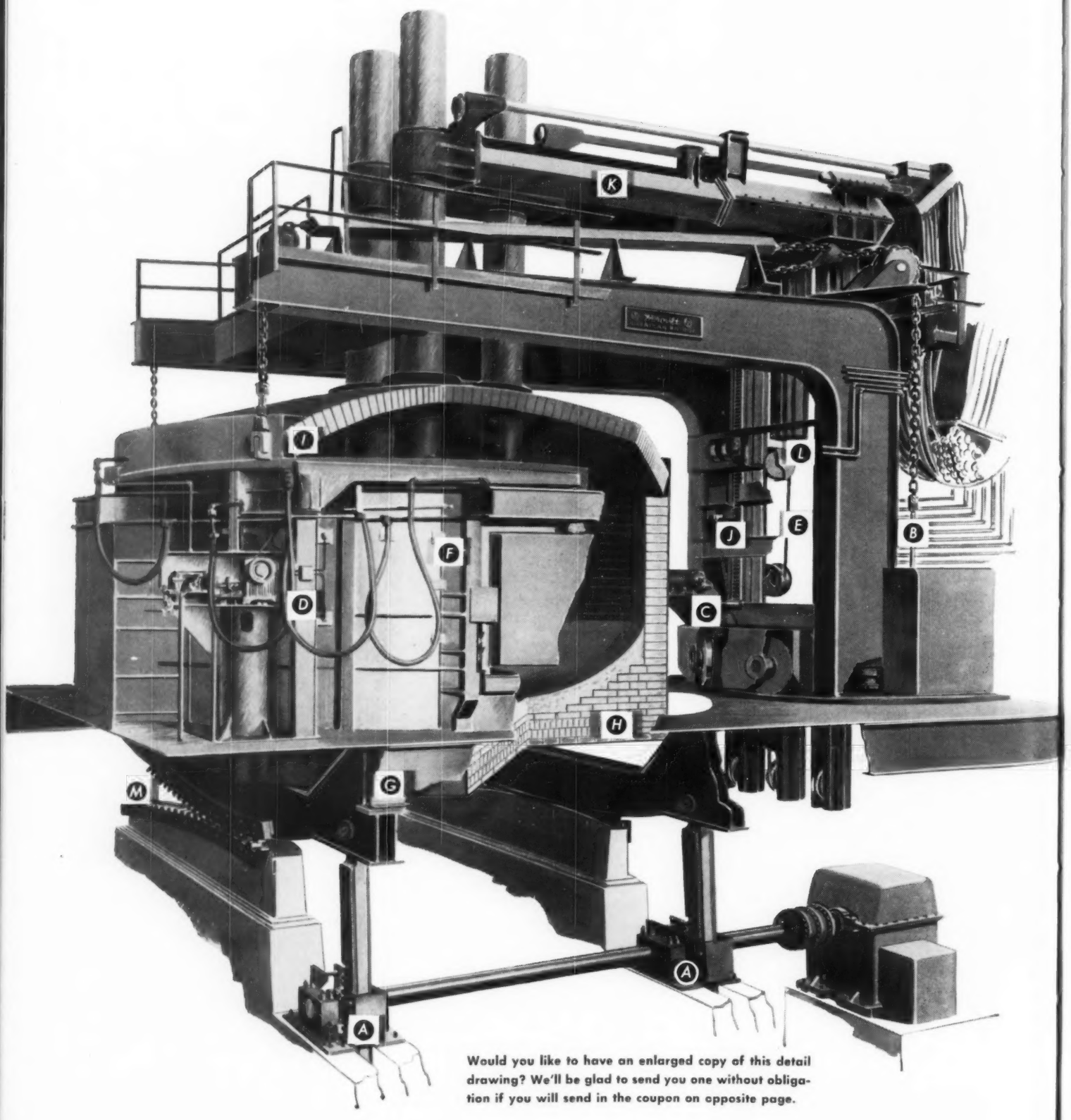
COMPLETE STRIP CLEANING EQUIPMENT FOR YOUR SPECIFIC REQUIREMENTS



This is a layout of a typical Rockwell strip cleaning installation. A single machine or several units—all Rockwell custom-engineered—may be integrated in a continuous processing system to meet specific production requirements. Write for Bulletin 440 to W. S. Rockwell Company, 2428 Eliot Street, Fairfield, Conn.

Famous Heroult Furnace redesigned . . .

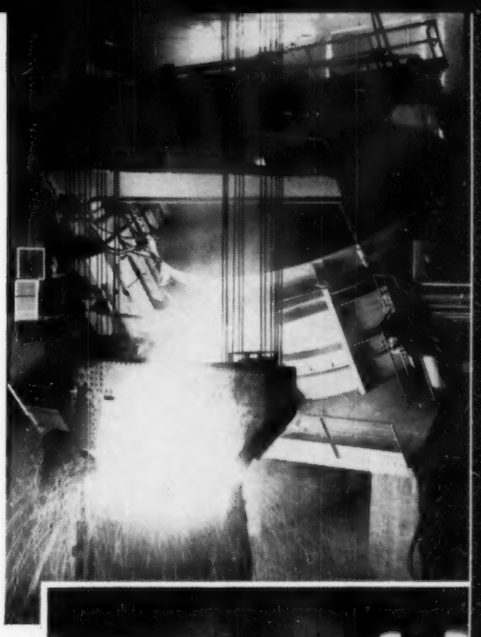
to help you keep down the cost of



Would you like to have an enlarged copy of this detail drawing? We'll be glad to send you one without obligation if you will send in the coupon on opposite page.

We welcome an opportunity to help you select and install the Heroult Furnace best suited to your requirements. Remember—*the Heroult we make and install for you will be the finest electric melting furnace that money can buy!*

electric furnace steel



To HELP YOU PRODUCE better quality steel faster and more economically, we have made important design improvements in the long-famous Heroult Electric Melting Furnace. Five of the features shown in the cutaway drawing at the left and described below are to be found *only* in the new Heroult. *All ten* of the illustrated features are important to those interested in the most modern melting equipment. Any way you look at it—performance efficiency, operating economy, or low-cost maintenance—this *new* Heroult is unquestionably the *finest* electric melting furnace on the market.

1. The Heroult Furnace is *the only 100% mechanically operated electric furnace.*

It includes such mechanical features as: (A) heavy rack-and-pinion-type tilting mechanism, (B) mechanical roof lift, (C) motor-driven, rotating, jib-type roof swing, (D) winch-operated, water-cooled, jib-type door-lifting mechanism, and (E) high-speed, electro-mechanical electrode-positioning mechanism.

2. *Another exclusive* — Cage-type shell construction with shell plates loosely attached (F) to a heavy supporting structure.

This construction minimizes shell warping and allows easy replacement of damaged shell plates.

3. *Exclusive* — Operating mechanism independently supported.

The tilting platform on which all operating mechanisms are supported is attached directly to the rockers independent of the shell structure (G). Thus operating mechanisms are unaffected by any shell distortion.

4. *Exclusive*—Flat Bottom Shell.

This feature (H) facilitates easy shell relining and provides maximum protection against burnouts. Thicker refractory at the sides of the hearth promotes more uniform bath temperature.

5. *Exclusive* — Water-cooled, Skew Back Roof Ring.

This feature (I) eliminates the need for special skew-shaped roof refractories.

6. Electrode Mast Safety Device.

This spring-loaded, rack-and-pawl-type device (J) provides positive protection against damage resulting from electrode winch cable breakage.

7. Square-Section, Water-Cooled Electrode Mast Arms.

This design (K) guarantees a rigid connection between mast and mast arm, thus helping to maintain proper electrode position.

8. Remote-Controlled Electrode Clamps.

This device, of the spring-clamp, air-release type, is located inside of the rear section of the water-cooled mast arm where heat cannot affect it.

9. Square-Sectioned Electrode Mast.

This design feature (L), developed by American Bridge, assures proper guiding and electrode positioning.

10. Rockers.

The heavy fabricated steel curved top and bottom rockers (M) minimize forward travel during tilting. These rockers are so designed that the furnace will tend to return to horizontal position from any degree of tilt.

THE NEW

Heroult

ELECTRIC FURNACES

are available in:

—sizes of shell diameter ranging from 7′ 0″ up, and with capacities of from 6,000 lbs. up to 400,000 lbs. and greater. They are equipped with roof-removing mechanism to permit fast top charging. They can readily be furnished with a non-magnetic shell bottom section to accommodate induction-stirring equipment.

Gantry-type top-charge furnaces, door-charge furnaces, and special furnaces for duplexing and non-ferrous melting can also be supplied.

Heroult

ELECTRIC

MELTING FURNACES

Send coupon for catalog and/or enlarged copy of detail drawing with special installation and engineering data.

American Bridge
Division of USS United States Steel

Contracting Offices in New York, Philadelphia, Chicago, San Francisco, and other principal cities. United States Steel Export Company, New York

Ame ican Bridge Division
525 William Penn Place, Dept. SE-58
Pittsburgh 30, Pa.

Please send me a copy of the latest Heroult Electric Furnace catalog ( ) and/or your new folder showing large drawing with special installation and engineering data ( ).

Name ..... Title .....

Firm Name .....

Address .....

City ..... State .....

(*Continued from page 161*)

It serves all industry in Chicago and extensive Mid-West areas through rail, truck or water shipments. It is located on the Chicago, South Shore and South Bend Railway within limits of the Chicago switching area. It is on a major district artery adjacent to the Interstate Toll Road System, and within a short distance of the Interstate Freeway. With frontage on the Grand Calumet River, the plant is advantageously located for water transportation, particularly with the impending development of the Great Lakes-St. Lawrence Seaway. The site is adequate for further expansion.

PA. TRANSFORMER OPENS SOUTHEASTERN OFFICE

△ Pennsylvania Transformer Division, McGraw-Edison Co. has announced the opening of a Southeastern district sales office at Atlanta, Ga. The new office will be headed by F. B. "Bo" Saunders, who has served for several years as factory sales representative in the Southeast and Southwest. He will be assisted in the Atlanta office by Elwyn G. Riley, sales engineer formerly associated with a manufacturer's representative in the same district.

The district to be served from the office, which will handle the sale of all Pennsylvania Transformer products, includes Ala., Fla., Ga., S. C., Tenn., and most of N. C.

How to cut mill downtime due to bearing failures...

use A·B·K* bearings

Roll neck and slipper bearings made of A-B-K material often outwear metal bearings many times. Their ability to cushion impact loads without peening, scoring or heat-checking protects roller necks, housings and chucks. Simplicity of design and light weight speed installation. Can be lubricated with grease, oil or water *alone*. Ask our engineers to help you solve your specific problems.

- Wear longer
- Won't score or heat check
- Light in weight
- Cut lubricant costs
- Save power

A·B·K
LAMINATED
PHENOLIC BEARINGS

*A registered trade-mark of American Brake Shoe Company in the United States and of Joseph Robb & Company, Limited, in Canada.

American Brake Shoe Company
AMERICAN BRAKEBLOK DIVISION
P. O. BOX 21, BIRMINGHAM, MICHIGAN

MORGAN REPRESENTATIVE MOVES TO NEW LOCATION

△ The Pittsburgh District Representative for Morgan Construction Co. has announced a change of address. Formerly located in the Koppers Building, Grant Street, Pittsburgh, Pa., the new location is 300 Cedar Boulevard, Pittsburgh 28, Pa.

APPLETON OPENS NEW WEST COAST FACTORY

△ The opening of a new West Coast plant and warehouse in Los Angeles, Calif., was announced by Appleton Electric Co.

Utah, Nevada and western Texas as well as the Pacific Coast states will be served on an overnight delivery basis from Los Angeles.

ARMCO STEEL ACQUIRES NATIONAL SUPPLY CO.

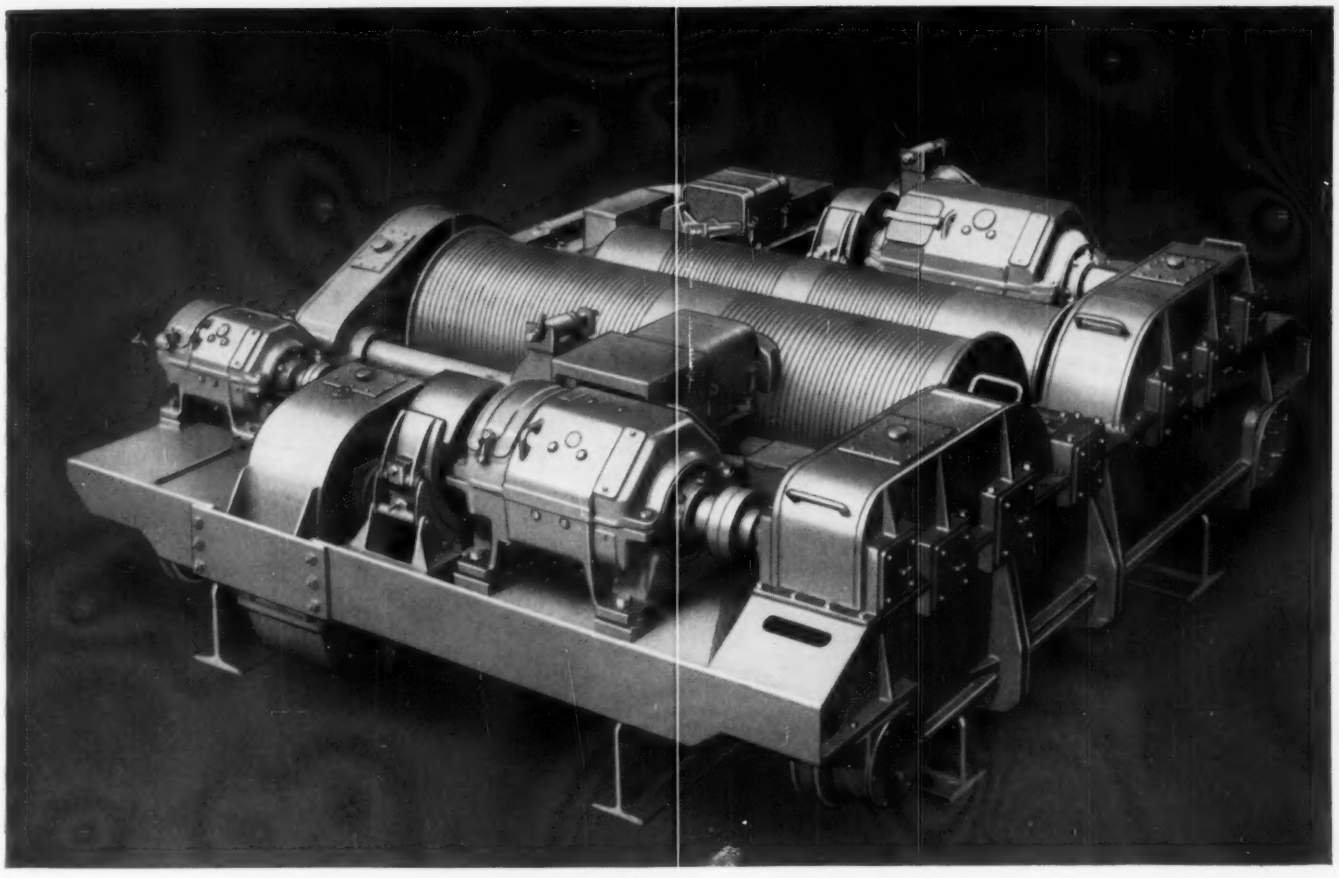
△ The merger of Armco Steel Corp. and the National Supply Co. was announced May 1.

A new National Supply board of directors composed of nine officers of National Supply and four of Armco Steel has been named.

With the addition of 12,800 National Supply shareholders Armco will have approximately 75,000 owners of its stock.

Meetings

△ A Materials Handling Conference will be held at the Penn-Sheraton Hotel in Pittsburgh, Pa., May 19–20. The conference is sponsored by the Pittsburgh Section and the Materials Handling Sub-Committee of the American Institute of Electrical Engineers.



VICTOR R. BROWNING *Trolleys*

FOR HEAVY DUTY MILL TYPE CRANES

"Simple Design is Sound Design"

We offer a complete line of trolleys built to meet the most exacting requirements. These trolleys are constructed of the finest materials available. No cast iron is used. All shafts are of highest quality alloy steel. All bearings are calculated with a proper life factor for service required as defined by the A.I.S.E. We will build a trolley to fit your special requirements as to gauge, head room, approaches and general arrangement. We also make a complete line of cranes for steel mill use. . . Your inquiries will be welcome.

VICTOR R. BROWNING & COMPANY, Inc.

BOX 309, WILLOUGHBY (CLEVELAND), OHIO

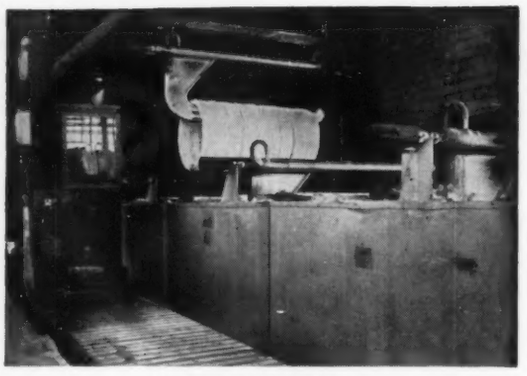
Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes

NO PICKLING PROBLEM Too Large or Too Small

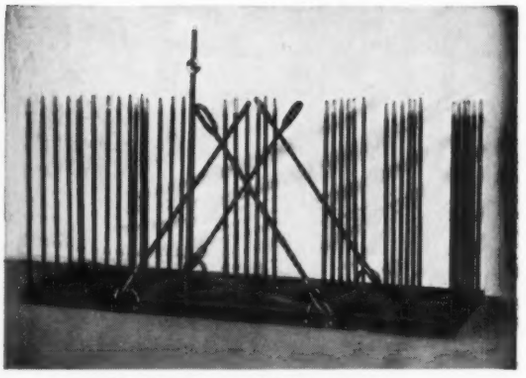
WELDCO Specialists Handle Them All!

IN HUNDREDS OF PLANTS, you'll find Weldco equipment all along the pickling line. For Weldco products are made of corrosion-resisting, hot rolled metals, that withstand attack from hot acids and other pickling solutions. They are strong yet light-weight, wear-resistant, durable, and long-lasting. You get all these advantages when you specify Weldco hooks, mechanical picklers, crates, baskets, racks, chain, steam jets, and accessories.

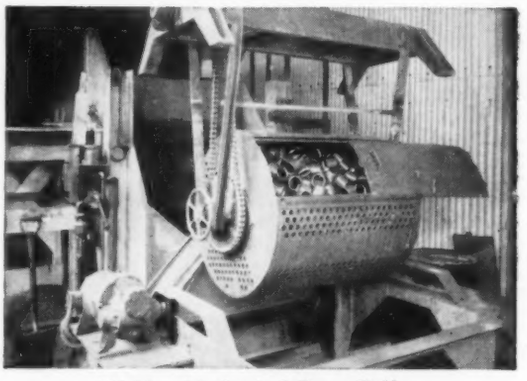
Weldco offers a complete, well-designed line of pickling equipment . . . plus the services of our experienced staff. Let Weldco engineers take care of all your pickling needs. For any problem, large or small, they have the practical, cost-cutting answer.



Weldco Pickling Hooks



Weldco Sheet Pickling Crate



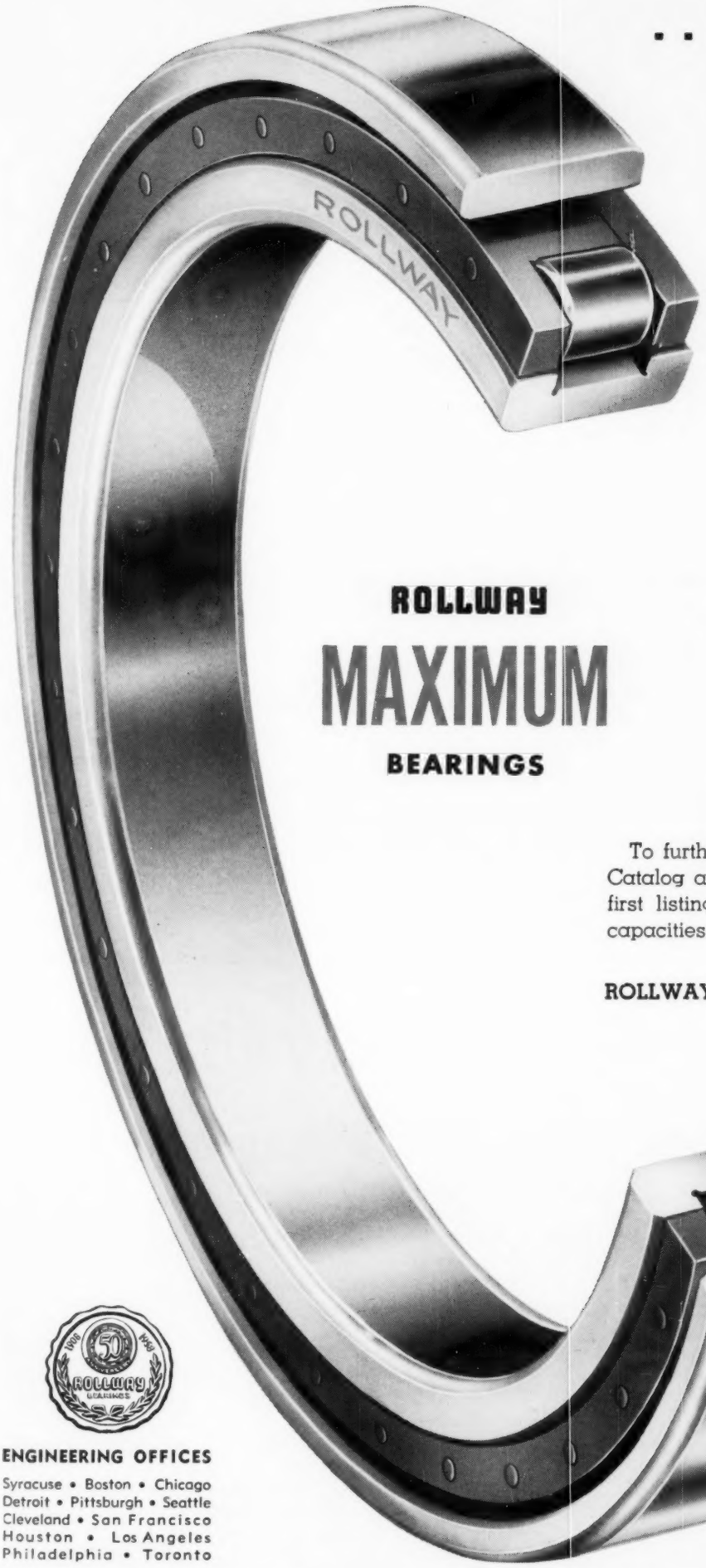
Weldco Mechanical Drum Pickler

Weldco Monel Chain

THE YOUNGSTOWN WELDING & ENGINEERING COMPANY

3724 OAKWOOD AVE. • YOUNGSTOWN 9, OHIO

. . . performance beyond the usual . . .



ROLLWAY

MAXIMUM

BEARINGS

Design of high-speed precision machinery often calls for bearings which offer the utmost in load capacity, "hot hardness", dimensional stability. Each machine presents its own exacting requirements.

Fulfillment of unusual requirement combinations is a specialty at Rollway. Your selection of exactly the right precision radial cylindrical roller bearing is assured by:

- **A broad range of types and sizes, numbered in the thousands**
- **Retainers of standard bronze or "Rollube" ferrous alloy, in roller-riding, land-riding, or broached construction**
- **Crowned rollers**
- **Modification of any factor to meet your application**

To further implement your choice, the Rollway Catalog and Engineering Data Book contains the first listing, by any manufacturer, of the thrust capacities of cylindrical radial roller bearings.

ROLLWAY BEARING CO., Inc., Syracuse 1, N. Y.

ENGINEERING OFFICES

Syracuse • Boston • Chicago
Detroit • Pittsburgh • Seattle
Cleveland • San Francisco
Houston • Los Angeles
Philadelphia • Toronto

ALLEGHENY LUDLUM STEEL CO. • ALUMINUM CO. OF AMERICA • AMERICAN BRASS CO. • AMERICAN CA
RON PIPE CO. • AMERICAN SMELTING & REFINING • AMERICAN STEEL & WIRE CO. • ARMCO STEEL CORP.
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STEEL COMPANY • BORG WARNER CORP. • BRAEBURN ALLOY STEEL • COLUMBIA STEEL CO. • CONNOR
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FOLLANSBEE STEEL CO. • FORD MOTOR CO. • GLOBE STEEL TUBE CO. • GRANITE CITY STEEL CO. • GREA
LAKES STEEL CO. • GREEN RIVER STEEL CO. • INTERLAKE IRON CORP. • JONES & LAUGHLIN STEEL CORP.
KAISER ALUM. & CHEM. CO. • KAISER STEEL CO. • KEYSTONE STEEL & WIRE CO. • KOPPERS COMPAN
NC. • LADISH COMPANY • LONE STAR STEEL CO. • LUKENS STEEL CO. • NATIONAL TUBE • NEWPO
STEEL CORP. • PACKARD ELECTRIC DIV. (GM) • PITTSBURGH COKE & CHEM. CO. • PITTSBURGH STEEL CO.
POLLACK STEEL CO. • REPUBLIC STEEL CORP. • REVERE COPPER & BRASS, INC. • JOHN A. ROEBLING'S SON
CO. • ROTARY ELECTRIC STEEL CO.
SLOSS-SHEFFIELD STEEL & IRON CO. •
A. O. SMITH CORP. • TENNESSEE
COAL, IRON & R. R. CO. • UNITED
ENGINEERING & FOUNDRY • U. S.
PIPE & FOUNDRY CO. • U. S. STEEL CORP. • UNIVERSAL CYCLOPS CO. • VANADIUM STEEL CO. • WEIRTO
STEEL CO. • WHEELING STEEL CORP. • WYMAN GORDON COMPANY • YOUNGSTOWN SHEET & TUBE CO

For 54 years...

Elliott Mill Motors have served the nation's leading metal producers

ELLIOTT'S NEWEST MILL MOTOR

delivers greater power . . . greater overload capacity

In 1904, Crocker-Wheeler introduced the *first* "Mill-type" motor . . . insulated with asbestos and mica . . . "bull strong." In the succeeding 50 years, C-W repeatedly introduced bigger, tougher mill motors to keep pace with the steel industry's needs.

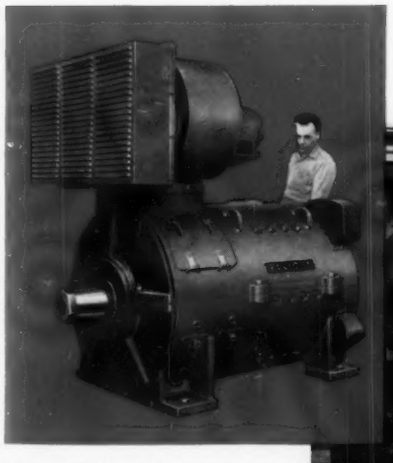
Today the Elliott C-W 620 Frame Mill motor extends the 600 series into the higher ratings required for bigger jobs. Rolled steel frame is horizontally split and all connections between top and bottom coils are brought out *external* to the motor. Windings are silicone insulated . . . entirely Class H . . . for longer life under extreme service conditions. Low inertia armature permits quick acceleration and deceleration. Tough and rugged, this motor remains especially easy to service and maintain.

More complete information on the 620 frame motor is included in Bulletin PB 9000-2. Bulletin PB 9000-1 covers 600 Frame motors in frames up to the 620.

ELLIOTT Company

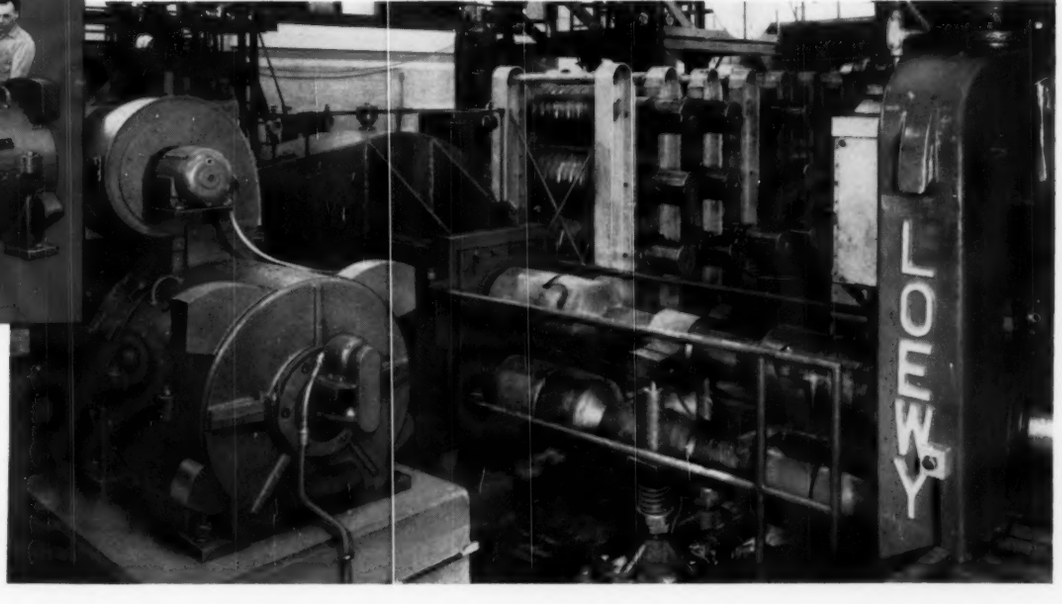
CROCKER-WHEELER PLANT, JEANNETTE, PA.

ELLIOTT C-W 620 FRAME MOTOR

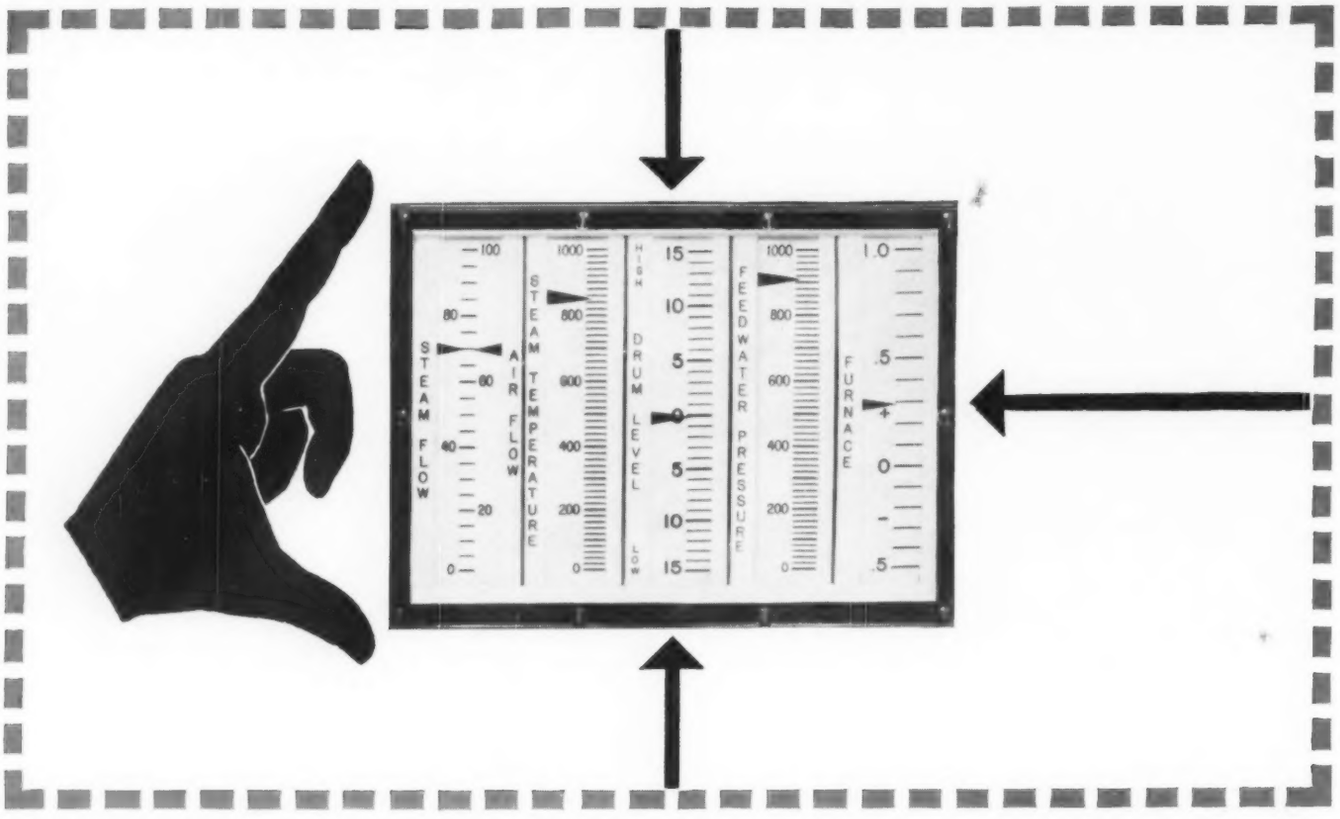


The Elliott 620 frame mill motor (above) in protected, forced-ventilated enclosure.

This Elliott C-W 620 frame motor (below) with a continuous rating of 350 hp, drives a two-high reversing mill. Enclosure is protected, forced-ventilated. Note ready access to commutator, even with top-mounted blower. Air vents are screened.



W8-4



Get big-gauge accuracy and sensitivity with

Republic's V5 Series of Compact Measuring Instruments

Two sets of Republic V5 gauges mounted on a modern console-type boiler control panel. Gauges match the compactness of the other instruments, yet are easy to read—even from a distance.

Republic V5 gauges feature full-sized diaphragms, bellows and helixes, yet require only one-fourth as much panel space as ordinary instruments. *Eight* V5 gauges can be mounted in a single bank requiring only about 14″ x 6½″. This compactness makes them ideal for console or graphic type panels. Each V5 gauge is an independent unit, which may be removed or replaced without disturbing adjacent gauges. Each 5″ vertical scale is illuminated from the rear for top readability—even from a distance.

A full line of V5 gauges is available for measuring draft, pressure, differential gas pressure and temperature, and for use as receivers with pneumatic transmitters for indicating flow, liquid level, density, high pressures and other process variables. If you would like to save panel space—without sacrificing instrument readability, performance and flexibility—a talk with your Republic engineer could be time well-invested. A card or a call will bring him. Republic sales offices are located in principal cities throughout the United States and Canada. Detailed information in Bulletin No. 806 . . . your copy is waiting.

A FEW OF THE OPTIONS AVAILABLE:

- Duplex bellows or helix gauges with two pointers operating on the same scale; occupies same space in group as a single-gauge unit.
- Set point indicator available on single bellows and helix units.
- Compound and reversed scales available.
- Reverse acting pointer motion available. (Can be reversed in the field without any change in parts.)
- High and low alarm contacts can be provided with all types of units.

REPUBLIC
FLOW METERS CO.

Subsidiary of ROCKWELL MANUFACTURING COMPANY
2240 DIVERSEY PARKWAY CHICAGO 47, ILLINOIS
In Canada: Republic Flow Meters Canada, Ltd.—Toronto
Manufacturers of electronic and pneumatic instrument and control systems for utility, process and industrial applications.

15 ton stripper crane built by PACECO for the Columbia Geneva Division of U.S. Steel. This crane is designed for around the clock operation at the company's Torrance, California, plant.

Chances are 1 in 5

If it's bid by PACECO it'll be built by PACECO

Let PACECO Bid Your Next Mill Crane

Put your specifications in the hands of experts, crane craftsmen who know how to cut costs without sacrificing performance... the result of 35 years of design-engineering-fabricating experience:

Proof: In 1957 PACECO was awarded over 20% of the amount of crane work bid!

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DUAL TORQUE* AND FLOAT CONTROL are new concepts in crane control by PACECO. These developments cut costs, increase crane efficiency. For more information write for brochure 4-D or contact your nearest PACECO office or representative.

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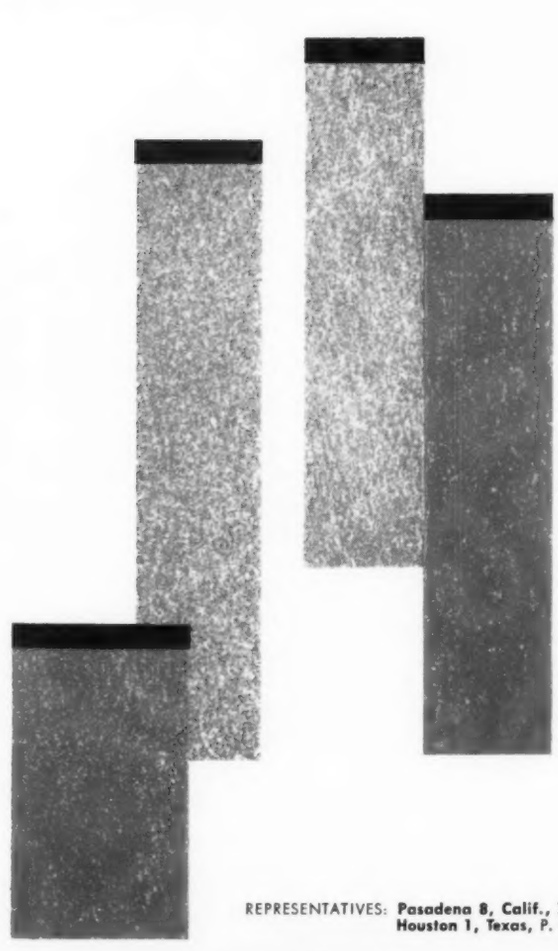

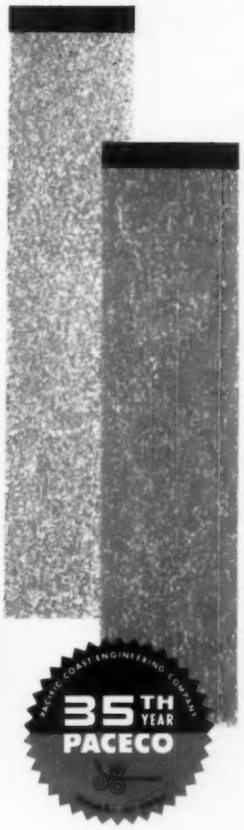

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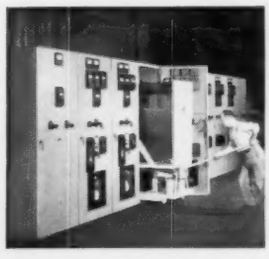
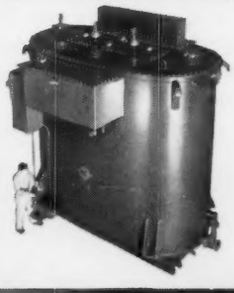
The arc furnace

Reduced costs result when Allis-Chalmers control, transformers and switchgear are specified for arc furnace application. The reason: A-C offers these products as a specially-integrated electrical system — designed by experts in furnace requirements and backed by Allis-Chalmers 75 years of experience in supplying equipment to the steel industry.

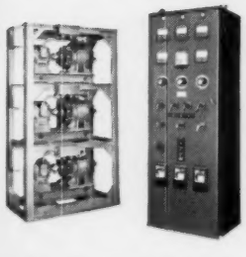
Wherever steel goes — from mine to final processing — Allis-Chalmers equipment is available to keep quality high, keep steel moving fast and profitably. Contact the A-C representative in your district, or write to Allis-Chalmers, Milwaukee 1, Wisconsin.



Arc furnace switchgear provides safe, dependable protection for transformer and related equipment. Special alloys assure long arcing contact life under severe interrupting duty, keeping maintenance and downtime to a minimum.



Transformers are of well-balanced designs and built for heavy duty . . . performance has been proven in 25-30 years of repeated daily short-circuits in electrical furnace operation.



. . . and Control requirements are met by Magnetic Amplifier and *Regulex* controls which balance arc current with arc voltage to maintain desired arc condition automatically. These controls result in high tonnage per kwhr, long life for electrodes and furnace linings, and a minimum of maintenance.

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Horizontal Extrusion Presses

During the past thirty-five years 315 SCHLOEMANN extrusion presses have been built. The outstanding performance record of these presses, based upon design innovations over the years, have resulted in increased economy of operation. Pioneering work carried out by SCHLOEMANN led to the design of the first 14,000 ton presses.

Close tolerances of the extrusions

Adjustable support of front-platen, container holder and moving platen.

Constant centering of tools, independent of heat emission.

Main ram guided by long bushings at both ends of the press cylinder.

Central guiding of the piercing ram over the whole length of the main ram.

Mandrel turning device for exact positioning of mandrel within the die.

Quick, economical operation

Automatic transport of billet, dummy and butt. Extensive automation to suit customer's requirements.

Rapid changing of all tools and easy removal of butt: die can be shifted longitudinally or transversely or it can be swivelled out—depending on the use of the press; billet container can be shifted.

Inside cooling and relative stroke of the mandrel to increase its life.

Pressure water station or self-contained oil-hydraulic drive—depending on the product, and on operating conditions.

Safe and quick operational sequence through preset sequence control. Numerous patents in Germany and other countries.

Technical data

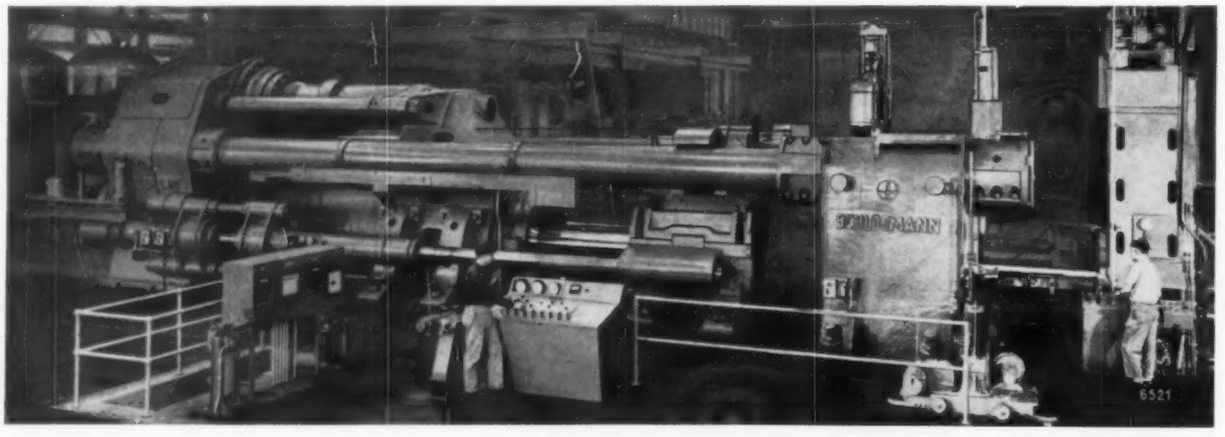
Frame-type	power 350 up to 700 tons
Three-column type or four-column type	power 700 up to 3850 tons
Four-column type	power 850 up to 25,000 tons

Extrusion presses with floating mandrel or spider-type tools power 350 up to 25,000 tons. Production: from solid billets....solid sections, wire (tubes). From hollow billets....tubes, hollow sections

Extrusion presses with mandrel shifting device, power 350 up to 25,000 tons. Production: from hollow billets....tubes, hollow sections. From solid billets.... solid sections, wire

Extrusion presses with piercer, power 700 up to 8,800 tons. Production: from solid billets....tubes, hollow sections, solid sections, wire. From hollow billets.... tubes, hollow sections, solid sections, wire

Extrusion methods "with shell" from cast billets; "without shell, lubricated" from machined billets.



14,000 ton extrusion press for tubes and rods in the Lafayette Works of ALCOA, USA, for light metal billets up to 32 in. dia, 70 in. length, weight 2½ tons. An additional press of this type is being built.

FELLER ENGINEERING CO., 1161 EMPIRE BUILDING, PITTSBURGH 22, PA.

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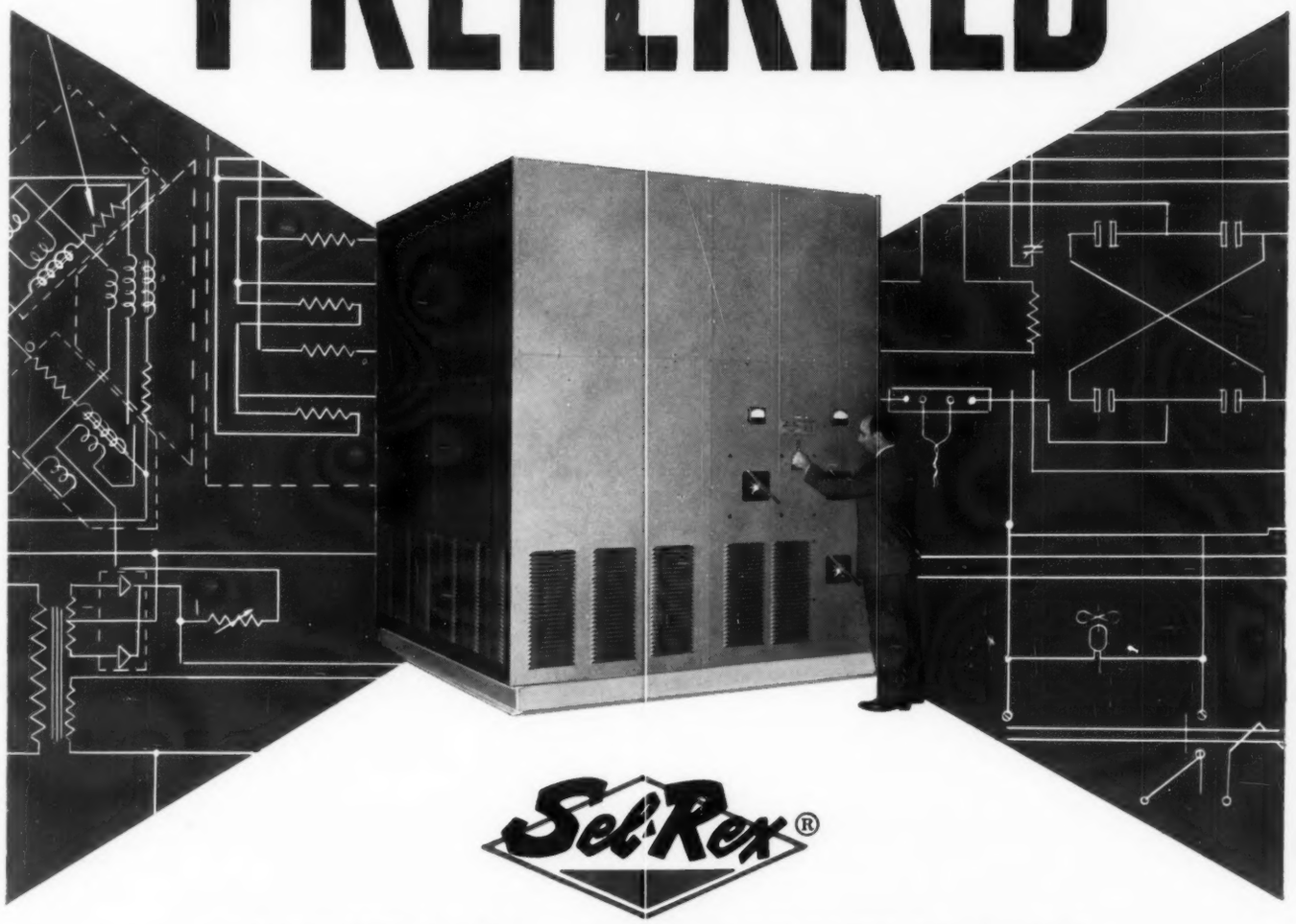

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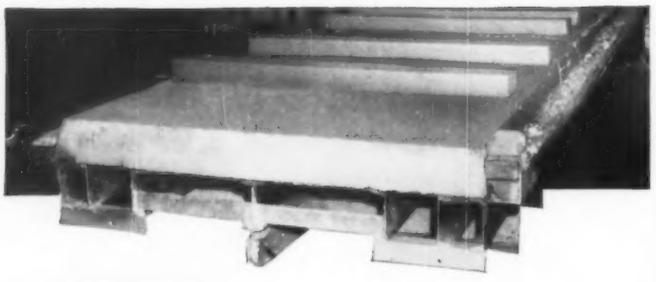
Complete Semiconductor Power Conversion Systems for any A.C. to D.C. application.

PLIBRICO LINING FOR CAR HEARTH YIELDS 50% SAVINGS



The actual installed cost for completely relining the car hearth shown was cut right in half, for the one-piece Plibrico lining eliminated $1100 worth of special alloy castings required along the sides to hold the ordinary fire brick lining in place. And a troublesome operating problem was solved, too, for these expensive castings would at times warp and freeze against the furnace sides, making it difficult to pull the car at the proper temperature.

Additional savings have resulted through the lower maintenance on this securely anchored 2-component castable lining. Plicast Tuff-Lite, used for its strength and insulating efficiency, protects the bed steel, cuts radiant btu loss. Over this is Plicast Tuff-Mix with excellent resistance to abrasion and thermal shock.

You can use Plibrico refractories and methods to your advantage. See how in our catalog covering Plibrico linings for industrial, foundry, and steel mill furnaces. Send today for your copy.

Plibrico REFRACTORIES ENGINEERING CONSTRUCTION

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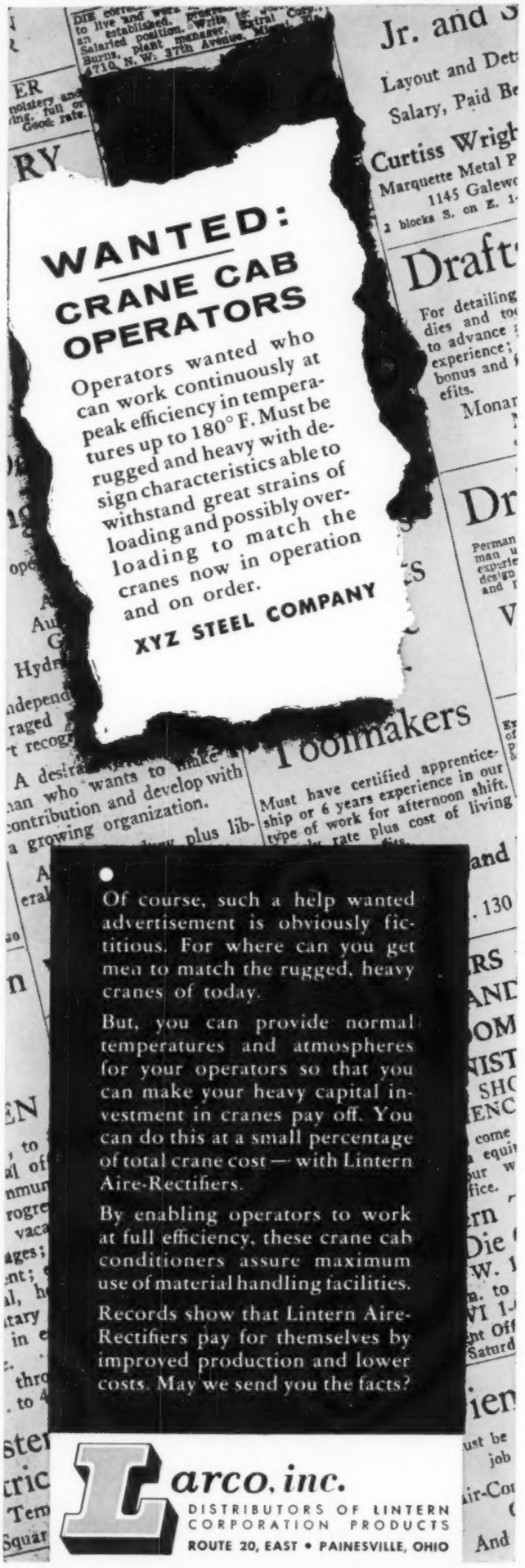
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CRANE CAB OPERATORS
Operators wanted who can work continuously at peak efficiency in temperatures up to 180° F. Must be rugged and heavy with design characteristics able to withstand great strains of loading and possibly overloading to match the cranes now in operation and on order.
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Toolmakers
Must have certified apprenticeship or 6 years experience in our type of work for afternoon shift.
Of course, such a help wanted advertisement is obviously fictitious. For where can you get men to match the rugged, heavy cranes of today.
But, you can provide normal temperatures and atmospheres for your operators so that you can make your heavy capital investment in cranes pay off. You can do this at a small percentage of total crane cost — with Lintern Aire-Rectifiers.
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Records show that Lintern Aire-Rectifiers pay for themselves by improved production and lower costs. May we send you the facts?
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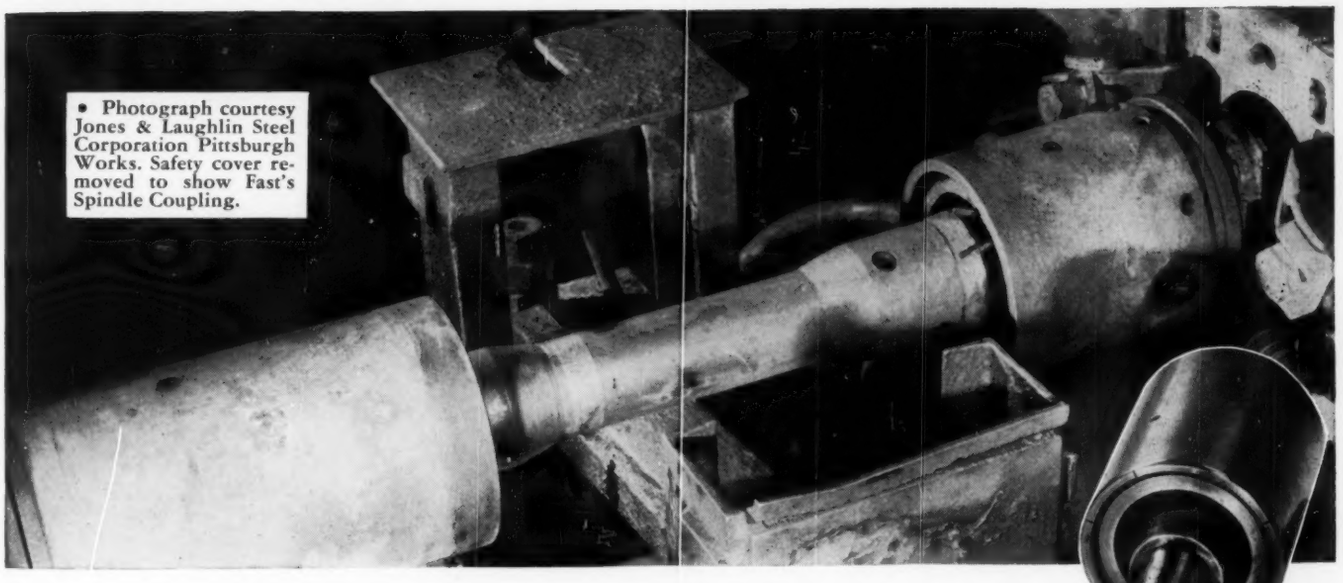

• Photograph courtesy Jones & Laughlin Steel Corporation Pittsburgh Works. Safety cover removed to show Fast's Spindle Coupling.

Fast's Spindle Couplings Mean More Profitable Rolling Mill Operations

★ *Up to 50% Less Down-Time*
★ *Quicker Disassembly*
★ *Bigger Savings on Maintenance*

The quick-disconnect and reliability features of Fast's Spindle Couplings may reduce down-time as much as 50%. Figured in dollars, this permits savings in production time in most rolling and blooming mill applications which can amount to thousands of dollars a month.

The new tooth configuration of Fast's Spindle Couplings compensates for a relatively high amount of misalignment with a minimum of backlash. It also permits constant angular velocity of the rolls which results in a marked improvement in the quality of the end product. Fast's Spindle Couplings are made of all steel construction with a metallic segmented conformable seal . . . completely self-contained and self-lubricated. They withstand the most rugged operating conditions, giving years of trouble-free service with only a minimum of maintenance.

Koppers' 38 years of experience in the coupling industry guarantees the right coupling engineered for a given application. To solve your rolling mill coupling problem write to KOPPERS COMPANY, INC., Fast's Coupling Department, 3005 Scott Street, Baltimore 3, Maryland.

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GALVANIZING LINES

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Two MESTA 48" Continuous Galvanizing Lines
with Feed Reels, Straighteners and Mash Welders

Designers and Builders of Complete Steel Plants

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MESTA
DESIGNERS AND BUILDERS OF COMPLETE STEEL PLANTS

Personnel News...

Albert J. Berdis has been named president of Weirton Steel Co. to succeed **Edwin O. Burgham** who now becomes chairman of the company's board of directors. Mr. Berdis comes to Weirton Steel from Olin Mathieson Chemical Corp. where he was vice president in charge of manufacturing for the aluminum division. He was appointed to the position in 1956 following a career of more than 25 years in the steel industry.

Mr. Burgham is a Weirton veteran. He began his service with the company in the metallurgical department in 1923 and advanced through many positions of increasing responsibility, including manager of the Tin Mill, general superintendent, and vice president in charge of operations. He became president in January, 1955.

Mr. Berdis' career in the steel industry dates from 1929 when he secured a position in the engineering department of the Gary plant of United States Steel Corp. He continued at this plant through 1935. In the following 21 years, Mr. Berdis carried out a variety of engineering, operating and administrative assignments with U. S. Steel, the last being general superintendent of South Works.

Paul Carnahan has been advanced from president to chairman of the Great Lakes Steel Corp. board of directors. His new position was previously held by **Thomas E. Millsop,** president of National Steel Corp. Mr. Carnahan has been succeeded as president by **Wilfred D. MacDonnell** who has moved up from the position of vice president—operations. **Charles G. Tournay**, vice president of Great Lakes Steel Corp., has been appointed assistant to the president of National Steel Corp.

Mr. Carnahan joined the Great Lakes organization in 1933 as an employee in the blooming mill department. He held several supervisory positions advancing to superintendent of the steel conditioning department in 1936 and superintendent of the hot strip mill department in 1941. In 1948 he was appointed director of production and remained in this position until 1953 when he was elected vice president in charge of sales. In 1954 he became senior vice president and then president of the company.

Mr. MacDonnell has spent his entire career in the steel industry. Starting as a combustion engineer in the open hearth department of Bethlehem Steel Co.'s Lackawanna, N. Y., plant in 1934, he became a general foreman and an assistant superintendent in this department. In 1946 he became assistant to the general manager of the Lackawanna plant and, in 1948, general superintendent of the steel division. In 1949, Mr. MacDonnell was transferred to Bethlehem's Johnstown, Pa., plant as assistant general manager. He resigned from this position early in 1957 to become affiliated with National Steel Corp. as assistant to the executive vice president in charge of special assignments and a short time later was elected vice-president—operations of Great Lakes Steel Corp.

William G. Stewart was reelected president and chief executive officer of Universal-Cyclops Steel Corp. **Donald W. Frease** was elected chairman of the board. He is president of Empire-Reeves Steel Corp., wholly owned subsidiary, and was a vice president of Universal-Cyclops. Mr. Frease succeeds **Edward L. Stockdale** who was named honorary chairman of the board. Mr. Stockdale has been associated with the company since 1914 and served as president from 1947 to 1956, and as board chairman since 1947. He will continue his participation in company affairs in an advisory capacity.

Thomas R. Adams was elected vice president in charge of Eastern operations, Detroit Steel Corp. Mr. Adams joined Detroit Steel in 1940 and has been general manager of the Eastern Mill Division.

Nicholas P. Veeder, president of the Granite City Steel Co., was elected to serve also as the company's chief executive officer and as chairman of its board of directors. Mr. Veeder, who has been with Granite City since 1934 and president since last year, was elected to fill the vacancy created by the death of **John N. Marshall.** Mr. Veeder has been in the steel business since

A. J. BERDIS

E. O. BURGHAM

PAUL CARNAHAN

W. D. MacDONNELL

N. P. VEEDER

C. M. BEEGHLY

M. K. SCHNURR

C. H. GOOD, Jr.

1933. He started with Granite City as an analyst in the chemical laboratory. He became, successively, assistant to the director of the Department of Metallurgy and Inspection, assistant superintendent of the company, production manager in charge of organizing an industrial engineering department to take care of job classifications and to supervise production scheduling for the mill, and works manager. In 1949, Mr. Veeder was elected to the newly-created position of vice president in charge of operations. He became a director of the company in 1953, executive vice president in 1956 and president on August 8, 1957.

Charles M. Beeghly has been elected executive vice president of Jones & Laughlin Steel Corp. Mr. Beeghly became president of J&L's newly formed Strip Steel Division on August 1, 1957, and was elected a director of J&L on October 31, 1957. **Martin K. Schnurr** succeeds Mr. Beeghly as president of the Strip Steel Division of Jones & Laughlin Steel Corp. In addition Mr. Schnurr retains his present duties as president of the company's Stainless Steel Division. Mr. Schnurr became president of the J&L Stainless Division, in Detroit, when it was formed in 1957 to operate the former Rotary Electric Steel Co. He also was elected to the board of directors of Jones & Laughlin last year. Before joining J&L, Mr. Schnurr had been president of Rotary Electric Steel for eight years. He had previously served as vice president of Bridgeport Brass Co.

Charles H. Good, Jr., was named to the position of chief engineer of Fairless Works, Central Operations of the United States Steel Corp. Mr. Good succeeds **Stephen P. Curtis,** who has been advanced to the post of chief engineer-Central Operations-steel and coal, with headquarters in Pittsburgh, Pa. Mr. Good started working for U. S. Steel at the Duquesne Works in 1939 while attending college. He was made assistant superintendent of Duquesne's utilities dept. in 1944, and four years later he advanced to assistant superintendent-assigned and operating maintenance. By 1950 he had become superintendent of that department. In 1953, Mr. Good was appointed assistant to the general superintendent and less than two years later he was promoted to chief engineer of the Duquesne Works. He was transferred to Pittsburgh in May, 1957, as assistant to vice president, maintenance planning—the position he held until the Fairless Works appointment.

John W. Carlson was named superintendent of the Blast Furnace Department, Pueblo plant Colorado Fuel and Iron Corp. Mr. Carlson succeeds the late **John W. Monson. Howard E. Pettefer** was appointed assistant superintendent.

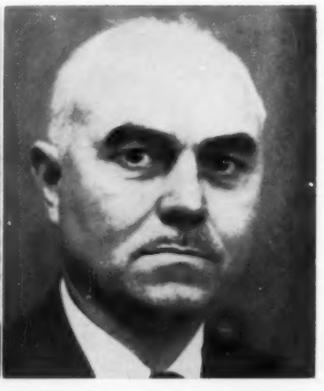
William G. Walk has been appointed assistant to vice president—maintenance planning of United States Steel Corp. In his new position Mr. Walk's duties will be concerned with maintenance on a corporation-wide basis. At the same time it was announced that **Frank O. Phillips** will succeed Mr. Walk as general superintendent of Johnstown Works and that **Willard U. Taylor** will succeed Mr. Phillips as assistant general superintendent there.

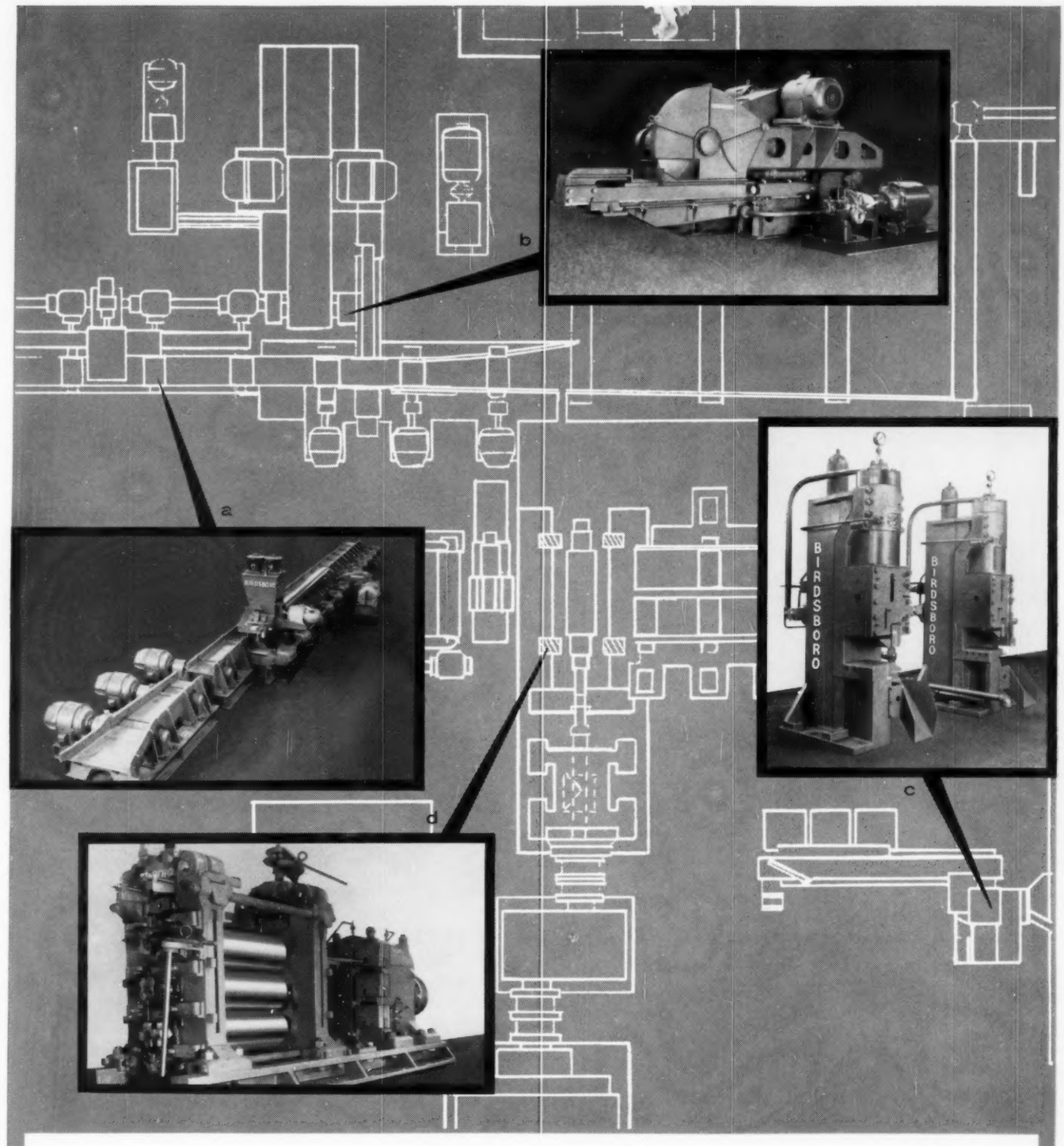
Mr. Walk began his career with U. S. Steel in 1930 as a metallurgical engineer at the Clairton Works. In 1932, he moved to the Homestead District Works as a metallurgical observer. He later became associated with the Wheel and Axle Division and was successively chief metallurgist, general foreman of the rolling and forge department and assistant superintendent. In 1943, Mr. Walk returned to Homestead as assistant superintendent of the No. 5 open hearth shop. He was successively assistant to the general superintendent of the plant, superintendent of the heat treating and forge division and, in 1951, division superintendent, central maintenance. In 1955, he was advanced to assistant general superintendent of the Johnstown Works and in 1957 was made general superintendent.

Mr. Phillips started with U. S. Steel in 1935, at Gary Sheet and Tin Mill as a wireman. In 1937, he was transferred to Irvin Works as an inspector during the construction of Irvin Works. He was made power foreman at Irvin Works in 1938 and was transferred to the Vandergrift Plant as assistant chief electrician in 1940.

W. G. WALK

F. O. PHILLIPS





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Main Office, Engineering Department and Plant: Birdsboro, Pa., *District Office:* Pittsburgh, Pa.

Illustrated above is a portion of a completely integrated Birdsboro merchant bar mill.

a. 54" Hot Saw Gauge b. 54" Hot Saw
c. 100 ton Crop Shears d. 16" 3-Hi Mill Stand

MM46-58

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In 1941 he was transferred to Homestead as tester engineer. During his ten years at Homestead he received several promotions and was superintendent of the 45-in. slabbing mill when he was made division superintendent of maintenance at Duquesne Works in 1951. He was made assistant to the vice president of operations with responsibility of maintenance planning in Pittsburgh in 1956 and assistant general superintendent of Johnstown Works in 1957.

Mr. Taylor joined U. S. Steel in 1946 as a practice apprentice at Homestead. In 1947 he was transferred to the Pittsburgh sales office. The following year he was transferred to the Tennessee Coal and Iron Division, where he held various positions, becoming staff assistant in 1952. Later that year he returned to the Pittsburgh Office of U. S. Steel as staff assistant to the administrative vice president—operations.

P. H. Reynolds has been appointed to the position of works engineer at the Pittsburgh Works of Jones & Laughlin Steel Corp. Mr. Reynolds, who was contract engineer in J&L's General Office, Pittsburgh, succeeds **W. Earle Black,** who retired May 1 after more than 32 years of service with J&L.

Mr. Reynolds was first employed as a wireman helper at the Aliquippa Works in 1928. He joined the Aliquippa Works' Engineering Department as a tracer in 1929, and was transferred as an electrical draftsman to J&L's Pittsburgh Works in 1930. He since has held positions as electrical squad leader, Pittsburgh Works; electrical engineer at J&L's Benson Mines, N. Y.; electrical engineer at J&L's Cleveland Works; assistant resident engineer at Pittsburgh Works; and staff engineer—Rolling Mills for the corporation. He was named contract engineer in 1956.

Mr. Black joined J&L as a supervising engineer at the Pittsburgh Works in February, 1926. He was promoted to project development engineer in 1956 and named to his present post in September of the same year. Prior to his J&L service, he held various engineering positions with Pressed Steel Car Co., Dravo Construction Corp., Witherow Steel Corp., National Tube Co. and Pittsburgh Valve Foundry and Construction Co.

Harlan W. Diefendorf has been appointed superintendent of melting at Crucible Steel Co. of America's Sanderson-Halcomb Works in Syracuse, N. Y. At the same time **D. L. Callahan** was named assistant melting superintendent. Mr. Callahan was formerly general foreman of the Melting Department. He is succeeded in that position by **William Crossett,** who has been with the company since 1926. Mr. Diefendorf joined Crucible in 1949 and held varied positions in the Metallurgical Department. For the past five years he has been assigned to the Melting Department. Before his present appointment he was assistant superintendent of melting.

Russell T. Jones has been appointed superintendent of the 10-12-14 in. mill at the Crucible Steel Co.'s Midland Works. Before his new appointment, Mr. Jones was assistant superintendent of the rolling mills at the Republic Steel Corp's Youngstown plant where he was employed since 1946. He was also employed at the Jones & Laughlin Steel Corp.'s Aliquippa works from 1930 to 1940 where his last position was that of foreman.

Norman J. Johnson was named manager of operations, A. M. Byers Co. He will be in charge of operations for Byers plants in Ambridge and South Side, Pittsburgh. Mr. Johnson was formerly associated with Follansbee Steel Corp. as general manager and consultant.

W. F. Munnikhuysen, chairman of the board of Koppers Co., Inc., since 1955, retired from that position, and the company's board elected **Fred C. Foy** to the dual position of president and chairman. Mr. Munnikhuysen, who reached the age of 65, remains however as a member of Koppers board of directors and will continue as a consultant.

William C. Germo has been appointed sales representative for Leschen Wire Rope Division, H. K. Porter Co., Inc. His territory will cover northern Illinois and southern Wisconsin except the Chicago metropolitan area.

Donald W. Johnson has been named manager of Reynolds Metals Co.'s aluminum reduction plant at Longview, Wash. Mr. Johnson succeeds **V. G. Kneeskern,** who has been named manager of the Reynolds St. Lawrence reduction plant at Massena, N. Y., now under construction.

H. Shenk was named vice president and technical director of Zurn Industries, Inc.'s over-all operations, including its Research and Development Division.

P. H. REYNOLDS

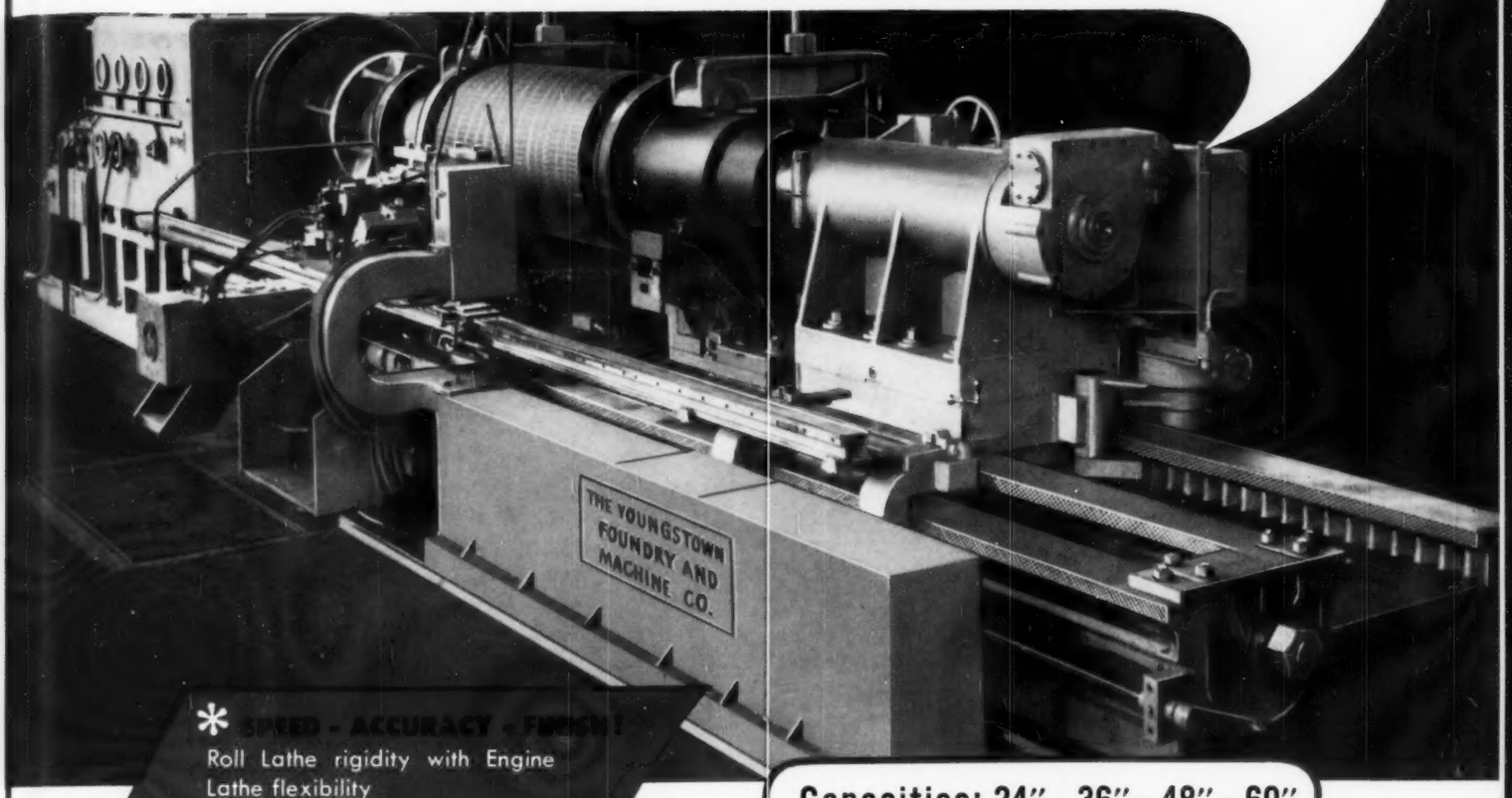
H. W. DIEFENDORF

R. T. JONES

N. J. JOHNSON

tomorrow's design in today's

Now "YOUNGSTOWN" Contour Roll Lathes*



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controlled automatically. Front mounted tracer and templet for operating ease and faster set-up

* NO FACEPLATE OVERHANG!
Faceplate supported by extra large Timken roller bearings mounted on extra large torque hub to carry heavy radial and thrust loads

* NEW TOOL POST & CARRIAGE
designed for either single point carbide-tipped tools or regular roll turning tools

* RUGGED HEAD STOCK!
Herringbone gearing; automatic lubrication; illuminated inspection ports

Turn rolls better and faster with Automatic Tracer Control

Far ahead in design and efficiency, this new roll lathe has been developed to turn rolls better and faster . . . either on necks or centers . . . from the smallest bar mill roll to the largest back-up roll. Tested and proved in our own roll shop. Capacities to meet your specific needs.

The 48" roll lathe pictured has a speed range of 1.40 RPM to 81.1 RPM. Roll capacities: 18" minimum diameter, 50" maximum diameter, with 20'0" maximum length. Hydraulic ragging attachment can be furnished, as illustrated. Tell us your requirements . . .

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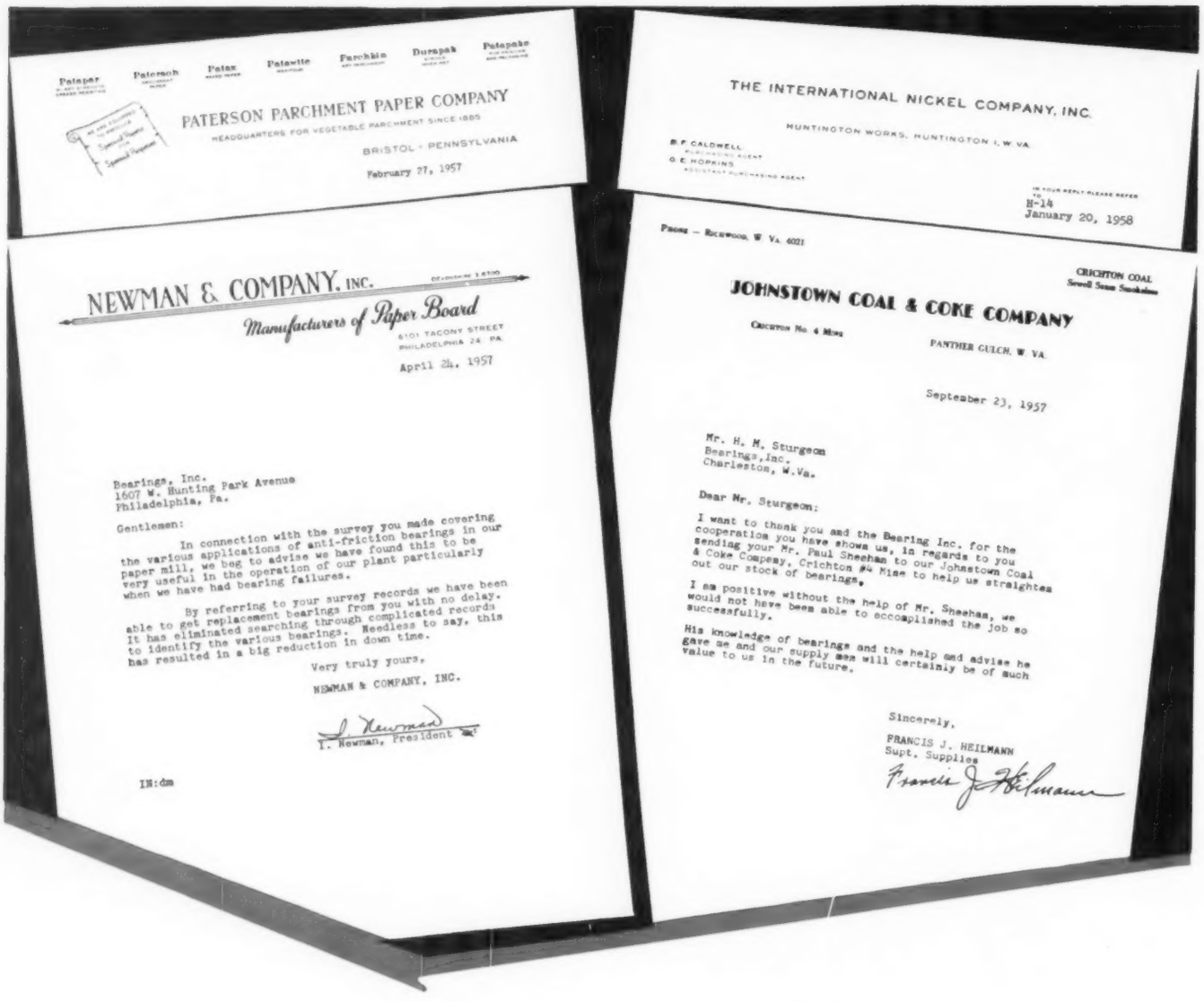

PATERSON PARCHMENT PAPER COMPANY
HEADQUARTERS FOR VEGETABLE PARCHMENT SINCE 1885
BRISTOL • PENNSYLVANIA
February 27, 1957

THE INTERNATIONAL NICKEL COMPANY, INC.
HUNTINGTON WORKS, HUNTINGTON 1, W. VA.
H-14
January 20, 1958

NEWMAN & COMPANY, INC.
Manufacturers of Paper Board
6101 TACONY STREET
PHILADELPHIA 24, PA.
April 24, 1957

Bearings, Inc.
1607 W. Hunting Park Avenue
Philadelphia, Pa.

Gentlemen:

In connection with the survey you made covering the various applications of anti-friction bearings in our paper mill, we beg to advise we have found this to be very useful in the operation of our plant particularly when we have had bearing failures.

By referring to your survey records we have been able to get replacement bearings from you with no delay. It has eliminated searching through complicated records to identify the various bearings. Needless to say, this has resulted in a big reduction in down time.

Very truly yours,
NEWMAN & COMPANY, INC.
I. Newman, President

IN:dm

JOHNSTOWN COAL & COKE COMPANY
Crichton No. 4 Mine
PANTHER GULCH, W. VA.
September 23, 1957

Mr. H. M. Sturgeon
Bearings, Inc.
Charleston, W.Va.

Dear Mr. Sturgeon:

I want to thank you and the Bearing Inc, for the cooperation you have shown us, in regards to you sending your Mr. Paul Sheehan to our Johnstown Coal & Coke Company, Crichton #4 Mine to help us straighten out our stock of bearings.

I am positive without the help of Mr. Sheehan, we would not have been able to accomplished the job so successfully.

His knowledge of bearings and the help and advise he gave me and our supply men will certainly be of much value to us in the future.

Sincerely,
FRANCIS J. HEILMANN
Supt. Supplies

Know what a Bearing Survey is? These companies do and they like the money it has saved them!

Bearings, Inc. located the bearings in the equipment in these plants — we took the parts numbers of these bearings and converted them to the bearing manufacturers' numbers. All bearings in inventory were examined and, where necessary, cleaned and rewrapped.

All bearings were catalogued and, where it was found that one bearing was used on several machines, as is often the case, it was possible to cut inventories of that bearing drastically.

These companies now have the survey and the Bearings, Inc. branch that performed the survey keeps a copy in its files. Together they work to keep bearing inventories at the minimum with the Bearings, Inc. branch making certain that it is holding, in reserve, the bearings these companies might require for any emergency.

They know, too, that the products they buy from Bearings, Inc. will be "factory fresh" latest type bearings. Bearings, Inc. sells only bearings for which they are authorized distributors.

Want us to make a bearing survey for you? There's no charge and you are not obligated in any way. Just call the Bearings, Inc. branch nearest you.

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INDIANA: Ft. Wayne • Indianapolis • Muncie • Terre Haute • **PENNSYLVANIA:** Erie • Johnstown • Philadelphia • Pittsburgh • York
WEST VIRGINIA: Charleston • Huntington • Parkersburg • Wheeling • **NEW JERSEY:** Camden
NEW YORK: Buffalo, Balanrol Corp. • **MARYLAND:** Baltimore • **DELAWARE:** Wilmington

and in the South ➤ **DIXIE BEARINGS, INC.**

FLORIDA: Jacksonville • **GEORGIA:** Atlanta • **KENTUCKY:** Louisville • **LOUISIANA:** Baton Rouge • New Orleans
N. CAROLINA: Charlotte • Greensboro • **S. CAROLINA:** Greenville • **TENNESSEE:** Chattanooga • Kingsport • Knoxville • Nashville

E. G. KLEIN

C. L. WEST

F. T. COPE, JR.

MAX DeHAAS

Mr. Shenk has returned to Erie after having been associated with a large eastern machine tool manufacturer as chief engineer for a number of years. Prior to that, he was associated with Zurn, beginning in 1934, in various capacities from chief engineer to vice president-administrative engineer.

E. G. Klein has been elected president of the Feller Engineering Co. He succeeds **Karl Feller,** retired, who continues to be a director of the company. Mr. Klein moved to Pittsburgh from Canada last year to join the Feller organization. He formerly was vice president of the Transocean Machine Co. and Transocean Trading, Inc., in Montreal.

C. L. West has been named chairman of the board of directors at The Electric Furnace Co. Mr. West, who has been vice president, will remain active in the management of the company. **F. Troy Cope, Jr.,** will become vice president in charge of sales. His father, the late **F. Troy Cope, Sr.,** was chairman of the board at his death in 1952 and the post has remained vacant since that time. Mr. West joined Electric Furnace Co. in 1929, and became vice president of the company in 1940. He has been a director since 1948. Mr. Cope joined the company in 1937. He became a director of the company upon his father's death in 1952. His first service with the company was in experimental work and as an erector in the field. Since 1945 he has been in sales, and in his new position will assume new administrative duties in the sales department.

Max DeHaas has been appointed vice president—Engineering by The Youngstown Foundry and Machine Co. Other Engineering appointments are: **Axel S. Hellstrom,** Chief Engineer; Frank J. Gentile, assistant chief engineer; Walter M. Keil, chief design engineer roll turning and contouring lathes, and Stephen Poleschuk, chief design engineer, extrusion presses.

C. Wesley Murray has been appointed manager of knife sales for Heppenstall Co. Mr. Murray started with the company in 1935 and has been a member of the Pittsburgh sales department since 1953.

Neal J. Crain, vice president and director of purchases, United Engineering and Foundry Co., was elected to the firm's board of directors, succeeding **Harry M. Naugle,** who has retired. Mr. Crain has served the company in various capacities for 45 years.

Ned W. Roudabush has been appointed manager of basic sales and technical service at the Refractories Division, H. K. Porter Co., Inc. Mr. Roudabush was previously with General Refractories Co. for 10 years in research and technical sales development.

H. David Honan, former assistant sales manager of switchboard section, Switchgear Division I-T-E Circuit Breaker Co., has been appointed manager, industrial sales. **Arthur G. Curtin,** previously midwest regional sales manager of BullDog Electric Products Co., an I-T-E division, has been named manager, contractor sales. These are two newly-created sales staff positions.

Mr. Honan joined I-T-E in 1948 as application engineer at Philadelphia headquarters. In 1949 he transferred to the Philadelphia district sales office as field application engineer where he became assistant district manager in 1955. In 1956 he was named to the position he held prior to this latest appointment. Mr. Curtin joined BullDog Electric Products Co. in 1945 as field application engineer in the Boston sales office. He became manager of BullDog's Philadelphia district office in 1952, after two intermediate assignments as field application engineer in Wilmington, Del., and Reading, Pa. In 1956 he was appointed BullDog's midwest regional manager, with offices in Chicago.

W. E. Gutzwiller was appointed assistant to the manager, and **T. H. Bloodworth,** chief systems engineer, Allis-Chalmers Manufacturing Co.'s Electrical Application Department. In other changes announced for the department's rectifier section, **D. B. Scott** becomes manager; **J. B. Rice,** chief design engineer, and **Harold Winograd,** consulting engineer. Mr. Gutzwiller, who had been manager of the rectifier section since 1955. came to Allis-Chalmers in 1931. Mr. Bloodworth has been with Allis-Chalmers since 1929 and had been supervisory engineer in the electrical application department. Mr. Scott came to Allis-Chalmers in 1937 and since 1955 had been assistant manager of the rectifier section. Mr. Rice joined Allis-Chalmers in 1935. Mr. Winograd has been associated with the design of rectifier equipment at Allis-Chalmers since 1931.

J. M. Crockett, assistant to vice president—gases of Air Reduction Sales Co., has been appointed manager of the Birmingham district. Mr. Crockett replaces **W. L. Poole** who has been named sales consultant

for the Birmingham district. Mr. Crockett began his association with Air Reduction in 1945 as an assistant metallurgical engineer.

Carl Claus was elected a vice president of The Babcock & Wilcox Co. Mr. Claus will continue to direct the activities of the staff division, which provides essential services to all divisions of the company. He joined B&W as an apprentice engineer in 1931, and became assistant superintendent of the company's former works in Bayonne, N. J., in 1937. The following year, he was made superintendent of the Refractories division plant in Augusta, Ga. He was advanced to executive assistant in charge of Refractories division sales and manufacturing in 1953, and was promoted to director of the staff division three years ago.

John G. Frischkorn, Jr., has been appointed sales manager of the Cleveland Tramrail Division of The Cleveland Crane & Engineering Co. He succeeds **A. F. Anjeskey,** who has retired after 30 years of service with the company. Mr. Frischkorn was formerly assistant sales manager.

Charles R. Gebel, sales representative in the Pittsburgh area for the Electrode Division, Great Lakes Carbon Corp., has been appointed manager of the company's new branch office in Pittsburgh. He joined the Electrode Division in 1954 as a sales representative in Pittsburgh. Previous to that he was with the Kaiser Aluminum & Chemical Sales, Inc., Jones & Laughlin Steel Corp., and The Timken Roller Bearing Co.

J. Elmer Forrest was appointed general sales manager—mechanical products, Diamond Power Specialty Corp. Mr. Forrest, assistant sales manager since 1948, has been with Diamond Power since 1924.

Harry C. Jackson has been appointed superintendent of maintenance at the Benwood Works of Wheeling Steel Corp. Mr. Jackson began his Wheeling career in 1950 as a practice engineer at the Benwood Works. In 1952 he was made an electrical engineer and, since 1953, has held supervisory positions in operations and maintenance at Benwood.

William F. Williams has been appointed supervisor of planned maintenance. He has been with Wheeling Steel since 1946, starting as a production engineer at the Benwood plant. In 1949, he became an estimator, and has since worked in engineering and operations at Benwood.

Carl R. Canfield has been named to the newly created post of chief engineer, product development department at Crane Co.'s engineering division. Mr. Canfield formerly was product development engineer in the spring division of Borg-Warner Corp.

John E. Hewson has been appointed manager of the New York sales region of The Foxboro Co. Mr. Hewson succeeds **E. H. Huckman,** who recently assumed the position of assistant field sales manager for the industrial instrument firm. Mr. Hewson joined Foxboro in 1949 as an instrument engineer in the Dallas, Tex., branch, and was later appointed branch manager of the company's Tulsa, Okla., office. Replacing Mr. Hewson as manager of the Tulsa branch is **D. T. McElligott,** a Foxboro field engineer at Dallas and El Paso since 1953.

L. Kermit Dowler has been appointed superintendent of the Cold Strip Department at Wheeling Steel Corp.'s Yorkville Works, and **Paul J. Pettit, Jr.,** was named assistant superintendent of that department. Mr. Dowler is a 23-year veteran with Wheeling Steel, and his entire career with the company has been at the Yorkville plant, beginning in 1935 as a production worker. In 1942 he was made a production engineer and five years later went into the Cold Strip Department as a turn foreman. In 1949 he became superintendent of cold strip box annealing. Since 1952 he had been assistant superintendent of the Cold Strip Department. In his recent promotion he succeeds **Owen K. Moynihan** who assumed new responsibilities at Wheeling Steel's Steubenville Works. Mr. Pettit began his Wheeling Steel career in 1950 at the Benwood Works as a practice engineer. In 1952 he was made a mechanical engineer at that plant, being transferred to the Steubenville Works later in that year as a technical assistant. In 1956 he was moved to the Yorkville Works as assistant superintendent of construction and, since 1957, had been assistant superintendent of the Mechanical Department.

Glenn P. Kraft has been named superintendent of the stainless steel department at Armco Steel Corp.'s Middletown Works. He succeeds **George E. Fahrenholz,** who has retired after 42 years of Armco service. Mr. Kraft joined Armco in 1928 as a lab man in the research division. The following year he moved to the metallurgical department as an analyst, and was a senior metallurgist when he was appointed a mill representative in 1946. In 1954, he became general foreman of the

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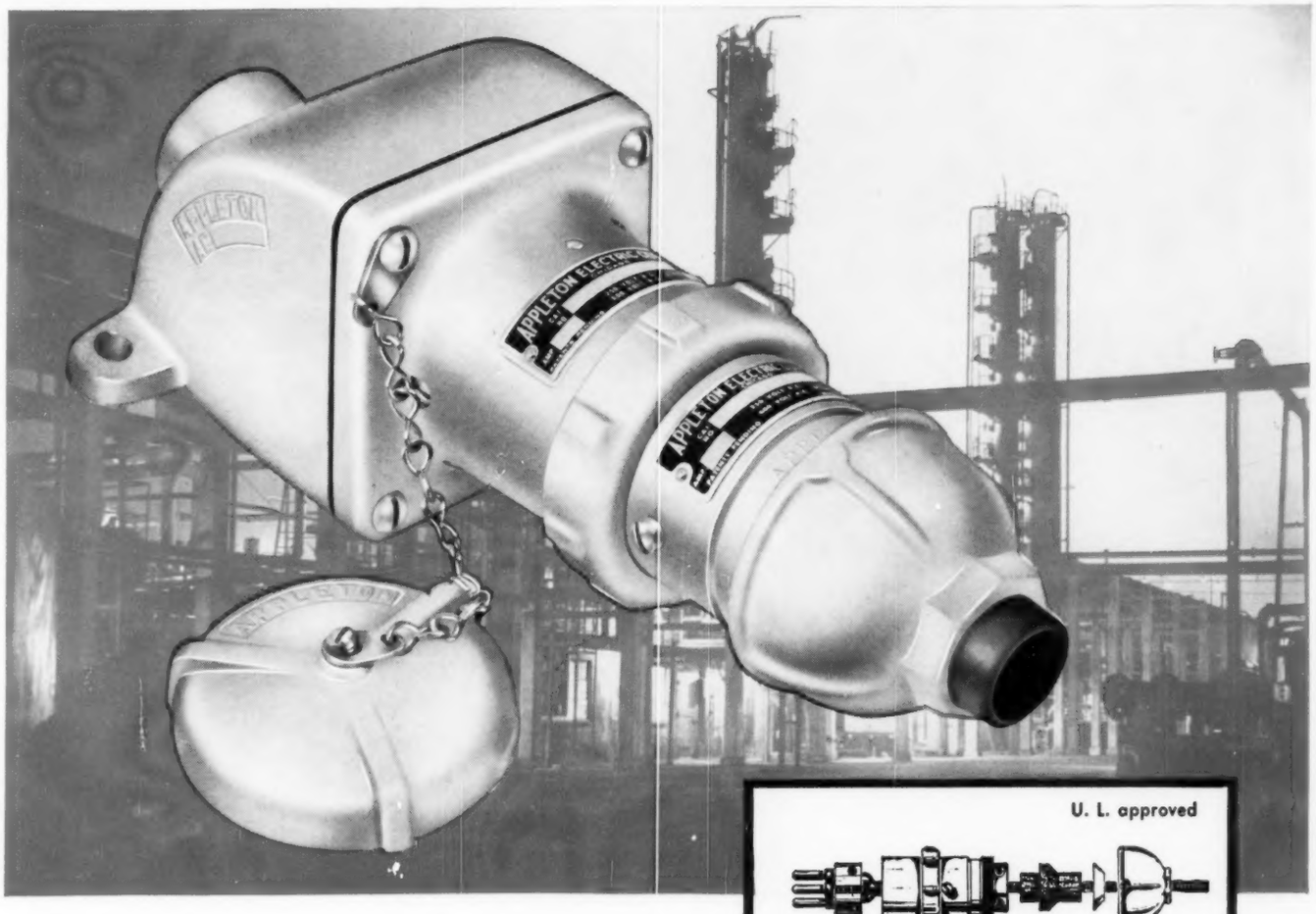

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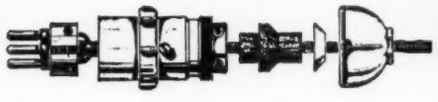

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The simple, sturdy construction of these APPLETON "AE" Series Plugs, Receptacles and Receptacle Fittings is your assurance of lasting, heavy-duty service.

Complete terminal units, equipped with solderless connectors enable connections to be made quickly with a minimum of effort. APPLETON "AE" Series Receptacle Housings are available in four styles to meet your specific requirements: Lift Cover Housing . . . Plain Housing . . . Threaded Housing . . . and Cap Housing. The Lift Cover Housing has a rubber-gasketed cover mounted on a self-aligning plate to form a dust-resisting enclosure which excludes chips, shavings, etc. Plugs are available with and without Clamping Ring. For utmost versatility and service life, APPLETON "AE" Series Plugs, Receptacles and Receptacle Housings offer an outstanding combination of quality features and economy of purchase.

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Twenty ton mill type bucket crane with 75' span built to A.I.S.E. #6 specifications, over the slag crushing plant in a large eastern steel mill.

20 Ton Bedford Mill Type Crane in slag crushing plant

The Bedford crane illustrated was designed for extra severe duty bucket mill type service — built strictly to A.I.S.E. #6 specifications. It uses a 3 cu. yd. capacity 4 line bucket. It is equipped with mill type 600 series motors, Tool Steel gears, pinions and wheels—forged steel flange type couplings are used throughout except all motor couplings are flexible type. The bridge is equipped with four two-wheel compensating trucks. The cab is equipped with safety glass on two sides, and each window is protected on the outside by sliding steel shutters to protect the operator from explosions in the pit. The cab floor is insulated to protect the operator from high temperatures in the pit.

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AGENTS

The Hank Thurstin Company, 475 Acoma Street, Denver, Colo., Phone RAce 2-4689

Central Station Equipment Company, 2323 Aviation Highway, Tucson, Arizona, Phone MAin 3-2493

Promociones Industriales, S. A., Apartado Postal 1468, Monterrey, N. L., Mexico, Phone 3-31-33

STEEL MILL CRANES BEDFORD

BEDFORD FOUNDRY & MACHINE COMPANY, INC. • BEDFORD, INDIANA

stainless steel department and was appointed assistant superintendent in 1956.

William R. Carlson has been appointed Press Division district sales manager in the New York area for the E. W. Bliss Co. Mr. Carlson takes over the position left vacant by the retirement of **L. R. Hills** on March 31. Mr. Carlson joined Bliss in 1947 as an administrative assistant in the company's Detroit general office. Since 1949 he has been a sales engineer in the Michigan and Ohio areas.

Gerald L. Moran was appointed vice president of the Chemical and Metallurgical Division of Sylvania Electric Products Inc. Mr. Moran also will continue as general manager of the division. He had previously been division chief engineer since 1954.

James J. Kerr has been appointed manager of the New York district office of Dodge Manufacturing Corp., succeeding **C. W. Brett,** who retired March 31 after 45 years with the company. Mr. Kerr worked for Somers, Fitler & Todd Co., industrial distributors in Pittsburgh, for eight years before joining Dodge in 1948. He was sales representative in the Pittsburgh district office of Dodge until coming to New York last October.

Ernie A. Schmidt, midwest regional sales manager, has been elected commercial vice president of I-T-E Circuit Breaker Co. Mr. Schmidt joined I-T-E in 1936 as an application and sales engineer at Philadelphia. In 1937 he moved to St. Louis and subsequently formed an agency to sell I-T-E products there. He transferred these agency operations to Chicago in 1945. In 1948 he was appointed district manager of the first I-T-E field sales office. I-T-E products, prior to that time, had been sold only by agents. In 1955 he was named I-T-E's midwest regional manager.

F. J. Waldschutz has retired as division engineer, Mesta Machine Co. Mr. Waldschutz joined Mesta 53 years ago, and has served as draftsman, chief draftsman, and for the last 30 years as division engineer.

G. R. Semans has been named director of metallurgy and **C. M. Carlisle** has been made director of analytical chemistry for Jessop Steel Co. Mr. Semans, who joined Jessop in 1955 as assistant director of metallurgy, assumes direction of the metallurgical laboratories, research projects and the quality control and the customer services sections. Mr. Carlisle came to Jessop in 1956 and became chief chemist the same year.

Owen K. Moynihan has been appointed assistant superintendent of the cold strip department at Wheeling Steel Corp.'s Steubenville Works. Mr. Moynihan is a 35-year veteran with Wheeling Steel, having started his career in 1923 as a production worker at the Yorkville Works. In 1935 he was assigned to the plant's new process department in a supervisory capacity. Three years later he was appointed assistant to the superintendent of that department. In 1943 Mr. Moynihan was named assistant superintendent of the cold strip department at Yorkville and, in 1952, he was promoted to the position of suprintendent of the cold strip department. He held that position until his appointment to the Steubenville post.

Frank C. Senior has been appointed manager of the Development Section of the Engineering and Construction Division of Koppers Co., Inc. Mr. Senior joined the Bethlehem Steel Co. as an engineer in 1936. He became associated with Koppers in 1946 as a contract engineer.

Obituaries

John N. Marshall, chairman of the board and chief executive officer of the Granite City Steel Co., died April 15. He was 60 years old.

Mr. Marshall left the Bethlehem Steel Co. in 1949 to become chairman of Granite City's board of directors. He had served as a director of Granite City since 1935. He was elected president of the company in 1950 and served in that dual capacity until 1956 when he became chief executive officer while continuing to serve as board chairman.

William A. Lintern, Board Chairman of the Lintern Corp., and Larco, Inc., died April 25. He was 54.

Sheldon K. Towson, president of The Elwell-Parker Electric Co., died April 3. Mr. Towson joined the company in 1927. His father, **Morris S. Towson,** founded the company before the turn of the century. He became president and general manager upon the death of his father in 1942.

Dr. George Vincent Slottman, 54, vice president—research and engineering of Air Reduction Co. Inc., died April 22. From 1927 to 1930 he was a professor of chemical engineering at the Massachusetts Institute of Technology. In 1930 Dr. Slottman joined the United Steel Companies, Ltd., Sheffield, England, as chief combustion engineer and iron works manager. He joined Air Reduction in 1934 as manager of the technical sales division, and in 1949 became director of research and engineering. His appointment as vice-president was made in 1952.

Frank H. Adams, president of Surface Combustion Corp., died April 6. He started his career in 1912 as project engineer in the Henry L. Doherty organization. When, in 1923, the Combustion Utilities Corp., a gas research subsidiary of the Doherty organization was founded in New York, he was elected vice president and treasurer. In 1924 H. L. Doherty bought Surface Combustion in New York. Mr. Adams was appointed its first treasurer and elected vice president and general manager in 1926. He became president in 1941.

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6000-TPH BELT CONVEYOR provides continuous handling of raw materials from ships to storage or screen house—performs a job deemed impossible with conventional transportation. Materials discharge from apron feeder to this 60-in. wide, 1260-ft. long conveyor on first leg of mile-long journey. System works year-round—in all weather.

How LINK-BELT developments in materials handling

stay in step

TRAVELING STACKER stores and blends materials. This 150-ft. radius unit beds materials in shallow windrows the full length of its runway, uniformly spreading materials of irregular composition throughout pile.

SHUTTLE BELT CONVEYOR, fed by "high line" conveyor, distributes coke into blast furnace stock bins. This highly flexible conveyor is reversible—provides low-cost materials distribution.

For basic raw materials—bulk handling equipment to keep pace with modern burdening techniques

TODAY'S blast furnace burdening techniques require higher tonnages of raw materials, more extensive storage areas and separate stockpiles for a greater number of ores. In furnishing complete, high-capacity handling systems for both new and expanding mills, Link-Belt helps avoid and relieve problems of storing and reclaiming ores, coke, stone, pellets and sinter.

Regardless of the size or physical layout of your mill, Link-Belt can help you coordinate material flow to fit into new processes . . . meet higher capacities of ship unloading . . . increase production. For facts, call your nearest Link-Belt office. 14,554

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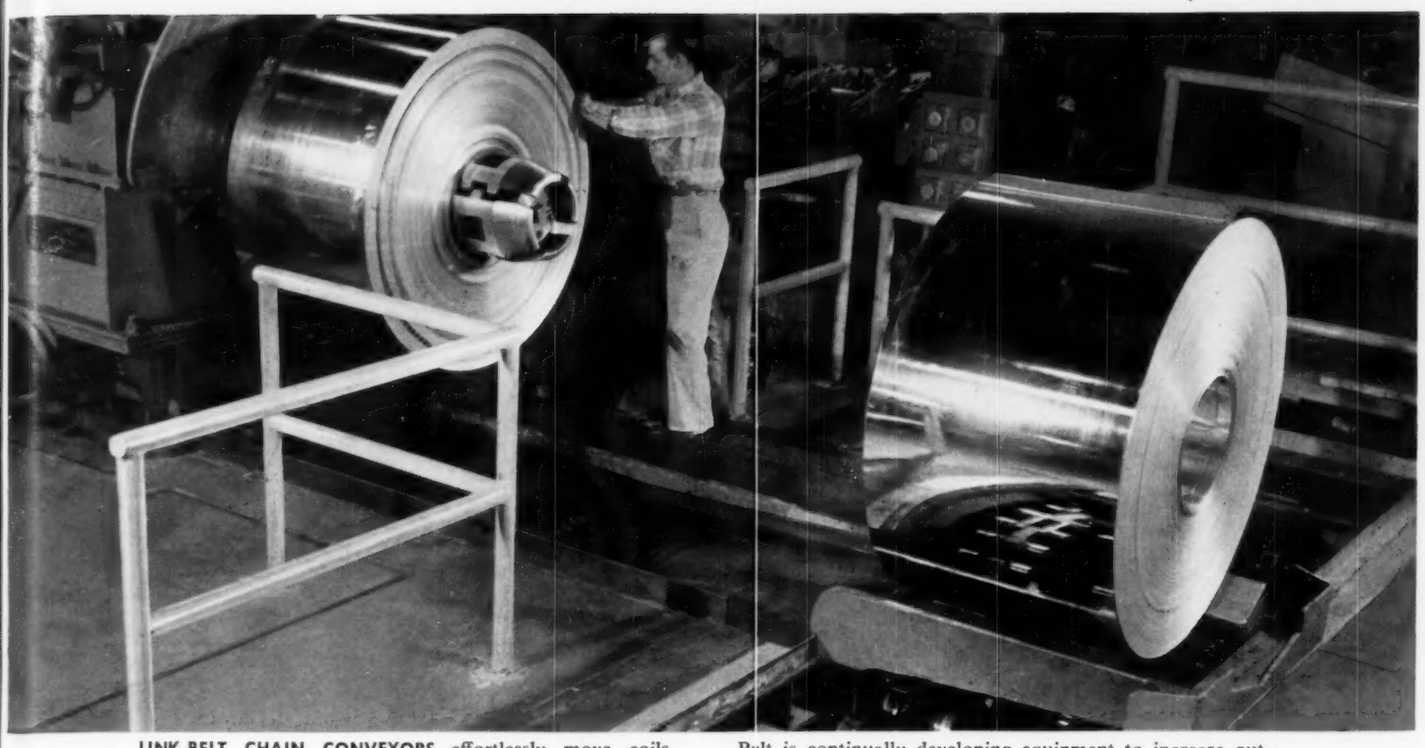

LINK-BELT CHAIN CONVEYORS effortlessly move coils weighing up to 75,000 lbs. Since product handling represents a large proportion of steel production costs, Link-Belt is continually developing equipment to increase output, lower costs and improve safety. Link-Belt offers a full range of conveyors designed to handle all steel products.

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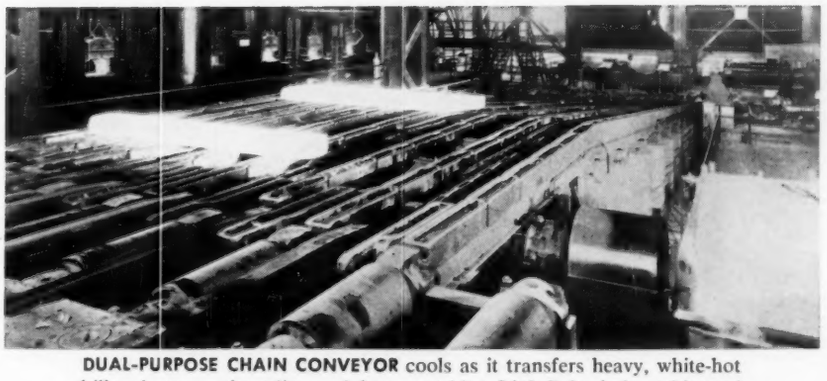
For steel in every form— conveyors to cut handling costs, improve safety, make better use of space

FROM white-hot billets to finished steel products, Link-Belt conveyors help modern mills boost yield, cut waste. Large tonnages are handled dependably, yet gently enough to reduce damage and scrap losses. By limiting crane movements and eliminating travel of vehicles in the vicinity of crews, safety is improved. Other Link-Belt equipment provides effective means for cooling hot products . . . provides active storage . . . permits existing processing equipment to be used to its maximum capacity.

Whether you're planning a new plant or modernizing, get in touch with your nearest Link-Belt office.



DUAL-PURPOSE CHAIN CONVEYOR cools as it transfers heavy, white-hot billets between shear-line and furnace tables. Link-Belt chains withstand continuous heavy loads and severe shock, resist abrasion and corrosion.

LINK-BELT PROMAL CHAIN with pusher attachments provides controlled cooling of longer pipe than previously possible. Conveyor receives tubes directly from furnace—controlled speed permits uniform cooling.

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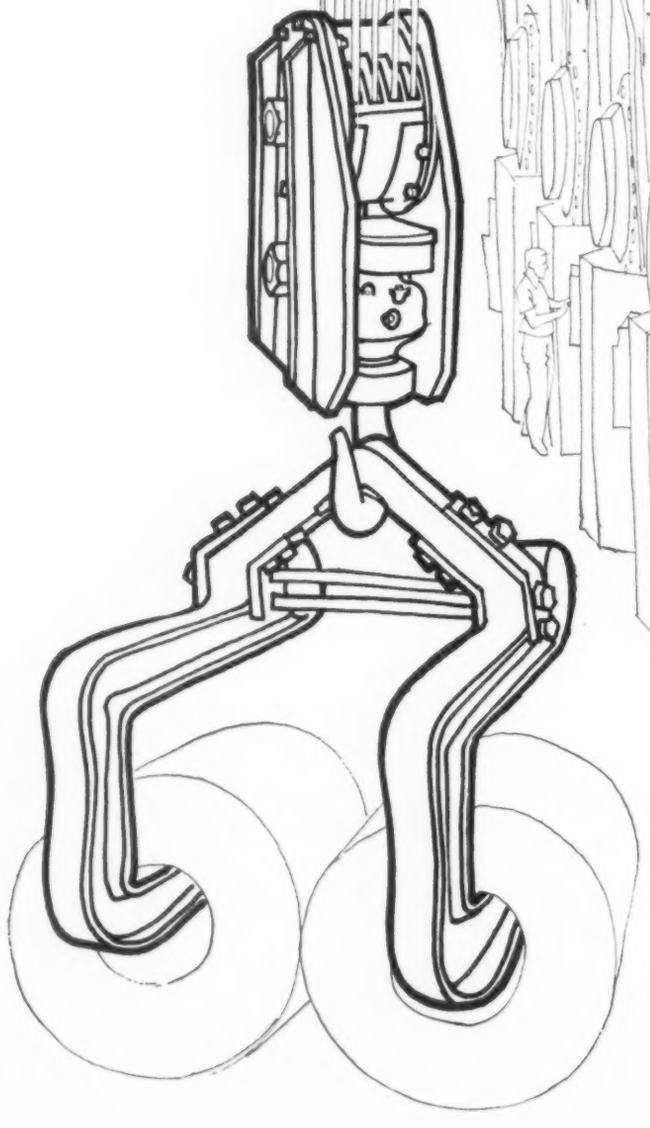
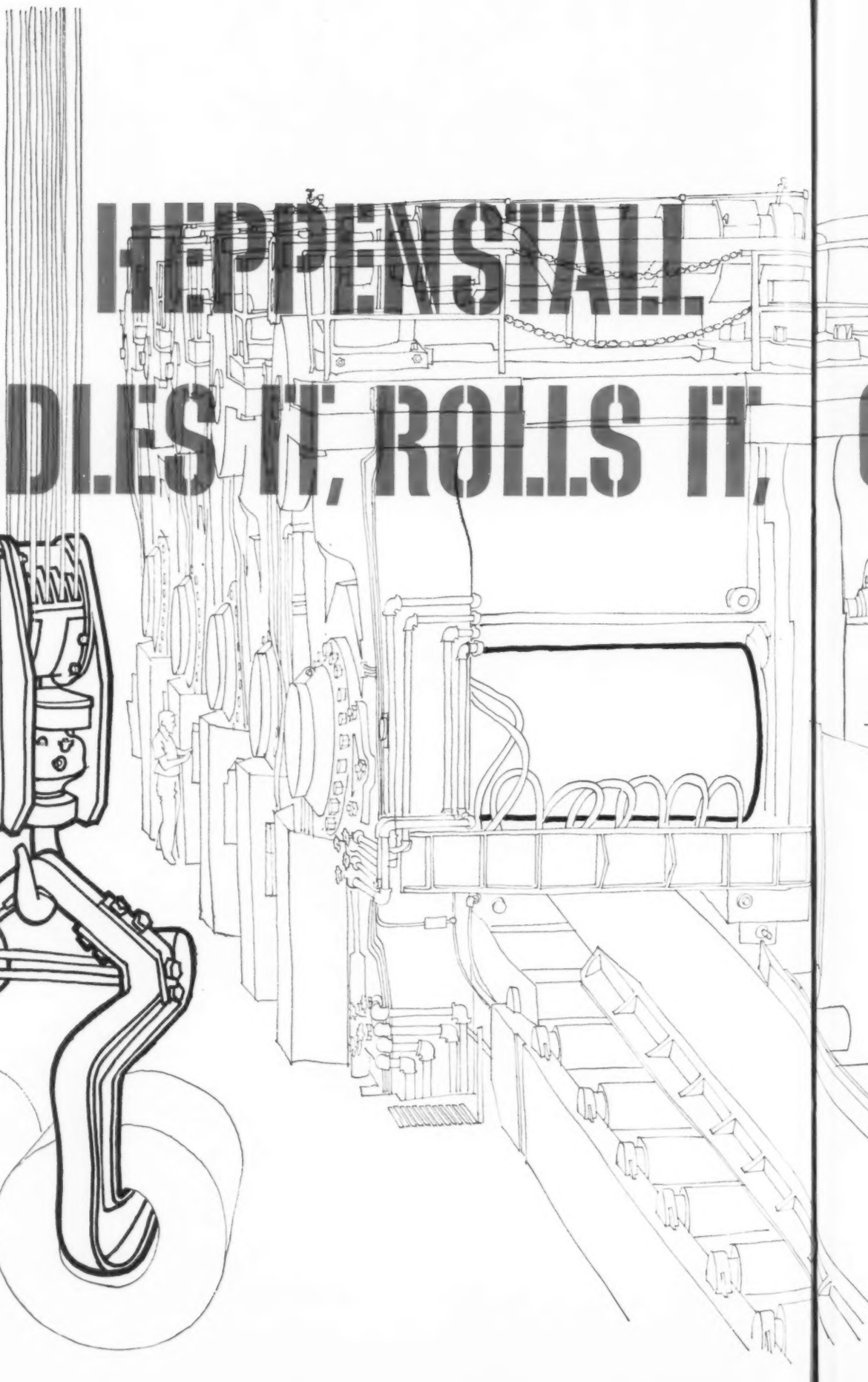
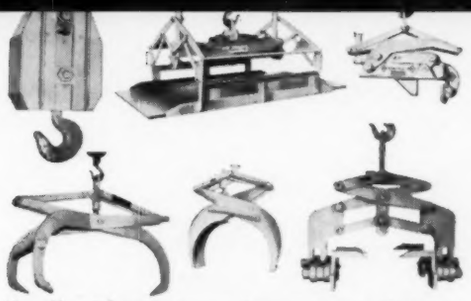




CUTS IT



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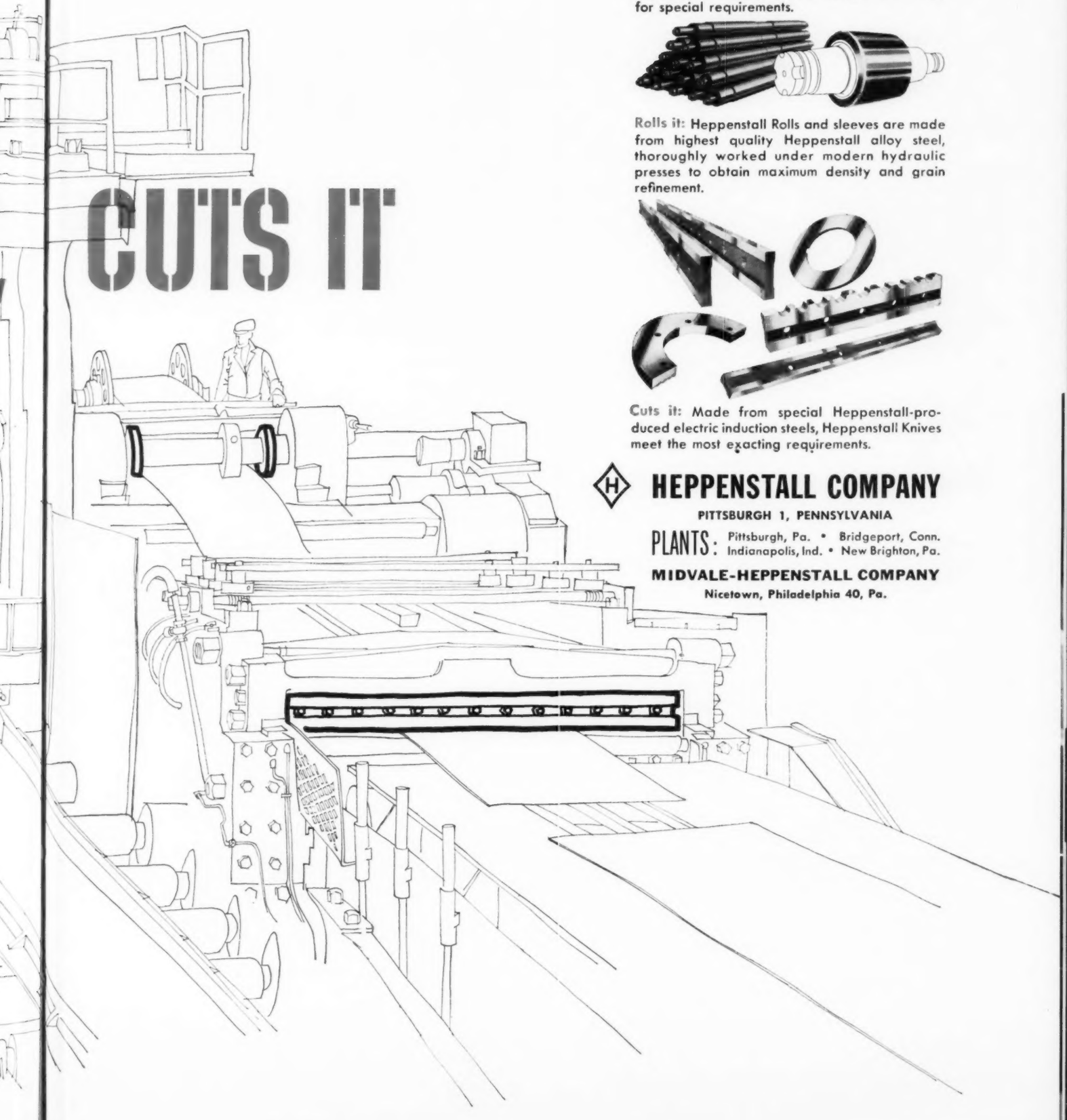

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No. 3

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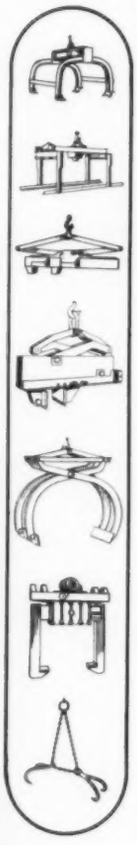

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"No secondary cleaner required with a P-A Washer"

...says FURNACE SUPERINTENDENT

This economical feature of the Pease-Anthony washer is only one of the many reasons why P-A is first choice with blast furnacemen.

It's a "natural" where high top pressures are used . . . puts full top pressure to work cleaning gas . . . low water consumption . . . low initial cost with minimum maintenance requirements . . . compact design requires little space.

Units available for capacities ranging up to 150,000 SCFM. Write for descriptive bulletin.

Performance summary of some P-A Washers now in use:

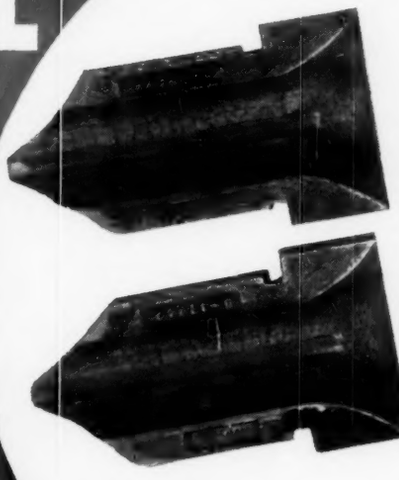
Installation	Years Operated	Volume SCFM	Pressure Drop Inches Water	Dust Loading Grains/SCF Inlet	Outlet
A	4	78,000	30	3-19.0	.01-.04
B	3½	78,000	30	2-3	.02-.08
C	3	85,000	30-40	2-3	.01-.03
D	3	45,000	30	2	.02-.03
E	½	75,000	50	—	.02
F*	½	26,000	12	5	.10
G*	½	26,000	12	5	.10
H	½	90,000	29	—	.04

Installation C is in Illinois. Installation H is in Texas. All others are in Pennsylvania.

*Two units in parallel on one furnace. Lower efficiency due to lower available top pressure.

CHEMICO
P-A GAS SCRUBBERS
CHEMICAL CONSTRUCTION CORPORATION
A Subsidiary of Electric Bond and Share Company
525 West 43rd Street, New York 36, New York
Telephone LOngacre 4-9400
Technical Representatives Throughout The World
Cable Address: CHEMICONST, N. Y.

TRANTINYL GUIDES THE STEEL INDUSTRY

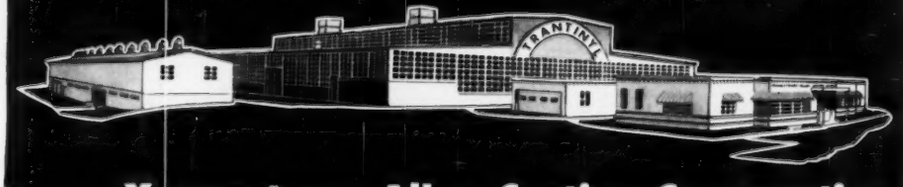


U. S. Steel Gary Works rolled 100,000 TONS with this pair of "TRANTINYL" GUIDES

These entry guides on finishing stand, 14" mill, were photographed after rolling 100,000 tons of rounds. Guides were still in serviceable condition.

14" Mill, Gary Works, with "TRANTINYL" Guides and Guide Box

"Trantinyl" Guides and Rollers hold exceptionally high tonnage performance records, in serving leading steel mills for a quarter-century.



Youngstown Alloy Casting Corporation
Youngstown, Ohio

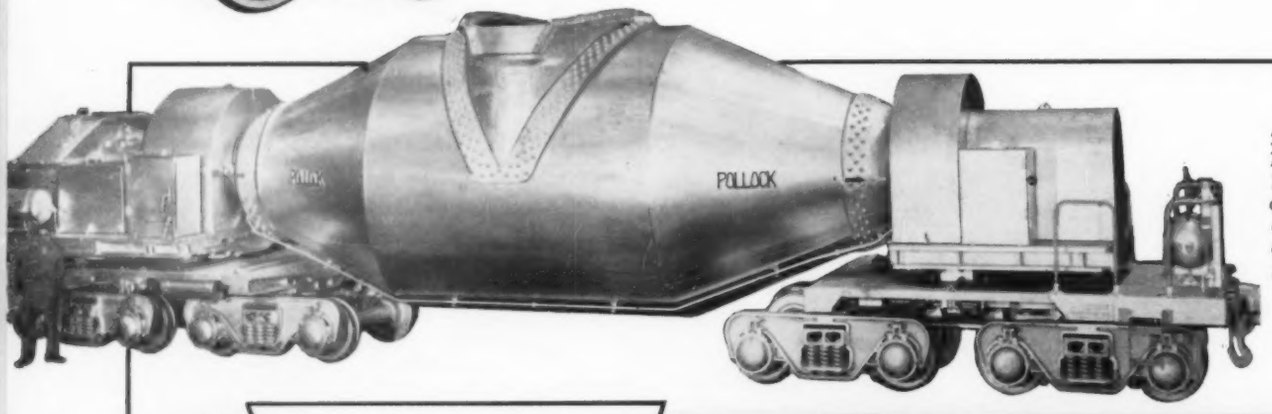
Sole Licensee to cast "TRANTINYL" for the Midwest, West and South: WAUNAKEE ALLOY CASTING CORP., Waunakee, Wis.

POLLOCK hot metal cars

These are America's newest, BIG, hot metal cars. Pollock designed and built this type car to carry large tonnages and reduce hot metal handling costs. Have Pollock analyze your requirements. Pollock will work with you to design the cars that meet your needs best.

150 NET TONS CAPACITY—16-wheel car. Spherical trunnion bearings protect against misalignment. Welded steel bodies and ladles. Pump lubrication of all gears and bearings in tilting drive.

170 NET TONS CAPACITY—12-wheel car has equalized BUCKEYE trucks for better performance on rough, uneven tracks, preventing derailments. Large ladle capacity materially lowers metal handling costs.



200 NET TONS CAPACITY—America's largest. Dumping mechanism is completely covered. Car designed to meet specific plant conditions. Air brakes if desired.

POLLOCK
SINCE 1863

THE WILLIAM B. POLLOCK COMPANY
YOUNGSTOWN, OHIO

Associated in Great Britain with Ashmore, Benson, Pease & Co.

STEEL PLATE CONSTRUCTION • ENGINEERS • FABRICATORS • ERECTORS

BLAST FURNACES • HOT METAL CARS AND LADLES • CINDER AND SLAG CARS • INGOT MOULD CARS • CHARGING BOX CARS • WELDED OPEN HEARTH LADLES

Publication Service...

MAY, 1958

You Can Obtain . . .

. . . any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

Note: Post cards expire three months after publication date.

(1) Cold Roll Forming

An 88-page reference manual which tells how to produce a wide variety of metal shapes by cold roll forming has been published by the Yoder Co. The handbook includes a clear and complete discussion of the economics, mechanics and possible applications of the cold roll forming process to various sized manufacturing operations—and offers assistance in selecting the correct size and capacity of equipment. Production costs, operating speeds, tooling, surface finish, uniformity, forming of precoated stock and personnel training and operating techniques are described in relation to the end uses and the raw stocks involved in a wide variety of examples. Special operations involved in continuous production of tubular, structural and ornamental cold formed shapes are described in the handbook. Complete "how-to" instructions on curving, coiling, ring-forming, notching, perforating, welding and embossing are included.

(2) Gear Generators

A new 32-page bulletin entitled "Farrel-Sykes Gear Generators" has been published by Farrel-Birmingham Co., Inc. It contains specifications, information on sizes and capacities and illustrations of machines in both the T and C series. Also included are descriptions of design features of these machines, which give them the capability of generating gears of all types which operate on parallel axes. (Bulletin 460)

(3) Motor Circuit Protection

Fundamentals of selective short-circuit protection for motor circuits are covered in a new bulletin by I-T-E Circuit Breaker Co. The eight-page bulletin reviews features and applications of the type ETI molded-case circuit breaker—an instantaneous magnetic-trip device specially suited for short-circuit protection of motor circuits and recommended for use in series with, and directly ahead of, the properly selected motor-running overcurrent trip device. The bulletin provides two pages of data tabulating the range of ETI frame sizes, their respective instantaneous-trip ranges and the suggested trip setting positions for various horsepower motors. (Bulletin No. 5040-A)

(4) Cast Iron Pulleys

A new 16-page catalog of cast iron pulleys has been issued by the Jones Machinery Div. of Hewitt-Robins, Inc. The catalog contains a listing of all standard pulleys and accessories manufactured by the company. Prices and instructions for ordering are included. (Bulletin J-15)

(5) Latch Relays

Described in a bulletin available from the Clark Controller Co. is a new line of mechanically-held latched-in relays. The bulletin outlines the features of the new latch relays, pictures all nine standard models with from two to 10 poles and both diagrams and pictures the space-saving possibilities. The numbers of circuits and combinations of normally-open and normally-closed contacts available are tabulated and a table of dimensions is included. (Bulletin 7305-PML)

(6) Hydraulic Oils

Sun Oil Co. has issued their revised bulletin entitled, "Hydraulic Fundamentals and Industrial Hydraulic Oils." This 44-page book is a practical introduction to the principles of hydraulic systems, with illustrated explanations of the most important types of valves, pumps, motors, torque converters and accessories. An explanation of important oil characteristics is followed by sections on oil selection and trouble-shooting. (Technical Bulletin B-4)

(7) Lighted Pushbutton Switches

Micro Switch, a division of Minneapolis-Honeywell Regulator Co., has published a data sheet describing a modular-mount series of lighted pushbuttons. The data sheet gives complete information of these switches. Photos of typical applications and dimension drawings are included. Also covered are electrical characteristics and prices. (Data Sheet 143)

(8) Vibratory Feeders

A revised edition of their vibratory feeder catalog has been released by Syntron Co. This 32-page booklet contains complete data and specifications for Syntron's thirteen standard vibratory feeders, three hydraulic and/or pneumatic feeders and spiral elevator feeders. Also included are pages of schematic layouts and feeder applications.

(9) Blast Cleaning

A 28-page handbook of blast cleaning, finishing and shot peening ideas utilizing the airless abrasive blast method is available on request from Wheelabrator Corp. A special section of this comprehensive handbook is devoted to the versatility of applications of Wheelabrator airless abrasive blast equipment in which more than 50 case history accounts are included. Covered are such diverse applications as cleaning of castings, forgings and heat-treated parts; deflashing of plastic moldings; reconditioning of auto parts, brake shoes, gas cylinders and steel drums; descaling of steel mill products such as sheet, strip, wire rod,

slabs and billets, etc. The balance of the booklet is devoted to specific types of Wheelabrator blast cleaning machines describing their applications, features and specifications.

(10) Rolling Mills

"Bliss Rolling Mills and Allied Equipment" is a publication showing a cross section of the products engineered and manufactured by E. W. Bliss Co. An informative and useful section is included which contains various formulas, tables and charts of interest to the steel mill engineer. (Bulletin No. 40-B)

(11) Precipitators

A 30-page booklet available from Research-Cottrell, Inc., describes the operation of its electrical precipitators, their performance and typical installations. Also included is a partial list of users.

(12) Synchronous Induction Motor

A synchronous induction motor built in the same NEMA frame size as a standard motor of equal horsepower in ratings from 1 to 100 hp is described in a bulletin released by The Louis Allis Co. Graphs and illustrations demonstrate design principles that enable the motor to accelerate as an induction motor and run at exact synchronous speed without permanent magnets or d-c excitation involving collector rings and brushes, wound rotating fields, etc. Uses for this motor are also discussed. (Bulletin No. 1900)

(13) Metalworking Machinery Catalog

An illustrated guide to modern metalworking equipment has been published by Ruesch Machine Co. Metalworking equipment for rolling ferrous and nonferrous materials is shown and described. Also included are installation photographs of rolling mills, straighteners, tube mill equipment and wire machinery. In addition, a cross section of accessory equipment is shown covering coilers, winders, reels, etc.

(14) Nonlubricated Compressors

Ingersoll-Rand Co. has published a flier describing their new line of nonlubricated compressors. A cut away drawing of a compressor cylinder for nonlubricating operation is included. Channel valves, frame and running gears are described also.

(15) Kiln Liners

Correct methods of installing basic refractory brick in the hot zones of rotary kilns are described in detail in the new booklet, "Kaiser Brick for Kiln Hot Zones," published by the Kaiser Chemicals Div., Kaiser Aluminum & Chemical Sales, Inc. The 32-page manual describes the step-by-step procedures for installing both Kaiser Unitab kiln liners and the conventional bare liners. Also included is information on material requirements, maintenance, ordering, shipping and handling. Tables are provided for quick, accurate computation of number of brick necessary to line kilns of most standard diameters.

(16) Cups for Pump Pistons

A bulletin describing the latest types of molded cups for pump pistons, hydraulic service and for pneumatic equipment has recently been published by The Garlock Packing Co. The new booklet, details the construction, recommended service and available sizes of synthetic rubber, leather, reinforced synthetic rubber, metal bonded and metal reinforced cups. The bulletin also contains tables illustrating the most popular cups for recommended services on a wide variety of general applications. A section is also devoted to the conversion from pistons designed for operation with hydraulic ring packings to pistons designed for use with pump cups. This includes pistons for tapered and straight rods. (Bulletin AD-145)

(17) D-C Crane Control Manual

A 20-page reference work on d-c crane controls has been published by The Clark Controller Co. In addition to being a complete catalog of Clark d-c crane control equipment, this bulletin is a manual on the selection and application of d-c crane control. Beginning with an explanation of the basic d-c hoist circuit, the manual continues through bridge and trolley motions and includes detailed coverage of the components which make up crane control systems. Special attention is paid to the need for and functioning of various safety and protective features. The illustrated, two-color publication also includes specifications, performance curves, component lists, tables of dimensions and other details of d-c crane control systems and components. (Bulletin 9100)

(18) Flame-Cutting Machines

Available from Linde Co. is a catalog describing their complete line of Oxweld flame-cutting machines. Complete specifications for each machine, illustrations of typical installations and a description of machine accessories such as automatic and magnetic tracing units are also included. (Form 4487)

(19) Vibratory Screens

Syntron Co. has announced availability of a new catalog on their vibrating screens. The bulletin lists complete data and specifications on magnet screens, concentric-action screens, unbalanced-pulley screens, grizzly bar screens and screening feeders. The bulletin is also illustrated with photographs of typical applications and installations.

(20) Industrial Television Equipment

A complete line of industrial television equipment is described in a brochure published by General Precision Laboratory Inc. The bulletin shows different types of cameras, control units, monitors, accessories and projection systems. Varied applications, including installations with unusual engineering requirements are also pictured and described.

(21) Comparison of Gas and Electric Strand Annealing Furnaces

General Electric Co. has published a bulletin that compares costs, efficiencies and heat losses of the two types of furnaces used to strand anneal wire continuously. The publication discusses data collected on the two furnaces over a month test period and contains pictures, graphs, curves and formulas. (Bulletin GER-1479)

(22) Gas Sampling System

Available from Bailey Meter Co. is a product specification describing their gas sampling system. Types of sampling tubes are described and illustrated as well as a discussion on their separate ap-

plications. A flow diagram of the entire system is also included. (Product Specification E65-6)

(23) Housings

The Adalet Manufacturing Co. has published a bulletin describing their cast-aluminum weatherproof and explosion-proof housings. Selection and specification data are included. (Bulletin 158)

(24) Magnetic Controllers

Westinghouse Electric Corp. has published a bulletin describing their heavy duty mill type d-c magnetic controllers. The bulletin lists the advantages of the all-steel d-c panel, contactors and relays. It also includes a list of accessories for these Westinghouse controllers such as master switches and grid resistors. (Bulletin B-7069)

(25) Indicators and Recorders

Concise information about electronic Speedomax G indicators and recorders for precise measurement of pressure, force, tension and weight using load cells is presented in a new illustrated 4-page data sheet just published by Leeds & Northrup Co. This sheet includes installation photographs of typical applications—checking static load in aircraft fuselage structural tests, recording weight of scrap charge to a foundry furnace, recording the weight of contents in 25-ton outdoor chemical storage tanks—and lists the features and specifications of the indicators and round- and strip-chart recorders. Load-cell characteristics are also tabulated. [Data Sheet ND46-20(1)]

(26) Metering and Control Systems

Available from Bailey Meter Co. is a new bulletin describing the purpose, design and operation of Bailey metering and control systems. A discussion of pneumatic and electric telemetering and pneumatic control is included, along with detailed literature references for all products making up these systems. (Bulletin 500)

(27) Cable Selection

Hints for electrical cable buyers on selecting the proper cable construction are contained in the pocket-sized 20-page booklet, "How to Choose Insulated Cable," just released by The Okonite Co. In easy-reading style it emphasizes the importance of examining all the facts surrounding each installation to be sure of obtaining the right cable for the job. Included is a typical check-list of the many technical points to be covered when preparing to specify an electrical cable circuit. Cable users will find it a handy reminder of the information needed when considering a cable problem or discussing it with a cable manufacturer. (Bulletin 1117)

(28) Electric Resistance Weld Tube Mills

The use of modern tube mills in the manufacture of pipe and tube is described in detail in the 64-page illustrated handbook "Electric Resistance Weld Tube Mills" published by the Yoder Co. The booklet provides a step-by-step description of the electric-weld process from roll forming and shaping of the tube to the finished product. Photographs, drawings and charts illustrate the operation, capacity and application of various sized electric-weld tube mills. The handbook offers advice in determining when a tube mill installation is justified and profitable.

(29) Welding Wire Guide

An 84-page welding wire pocket guide available from Air Reduction Sales Co., has quick and convenient answers to almost every question that can be asked about welding wire for use with Airco's gas-shielded metal arc—or Aircomatic—welding process. The booklet presents the varieties of wire types, wire diameters and packaging data. It also contains technical information such as chemical composition, mechanical properties, and operating procedures. Conformances and approvals are shown for each wire where applicable. (ADC 873)

(30) Vacuum Arc Furnaces

An eight-page publication, emphasizing savings in cost and space, reduced maintenance, maximum utilization and manufacturing quality made possible by vacuum-arc melting as a production technique, is offered by General Electric Co. The bulletin describes the principle used in designing such furnaces and discusses in detail the components, controls and instrumentation of GE's vacuum arc furnaces for laboratory, pilot plant and production operations. Publication also points out advantages of the company's silicon rectifier arc furnace power supply.

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IRON & STEEL ENGINEER

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50	ADAMS CO., INC., R. P.	BULLETIN 711	Aftercooler and cyclone separator
51	AJAX FLEXIBLE COUPLING CO., INC.	CATALOG NO. 64	Spindle couplings
52	AMERICAN AIR FILTER CO., INC.	BULLETIN 248-C	Air filter
53	AMERICAN BRIDGE DIV., UNITED STATES STEEL CORP.		Electric melting furnaces
54	ASKANIA REGULATOR CO.		Automatic controls
55	ATLAS CAR & MFG. CO.	BULLETIN 1283	Transfer cars
56	BAILEY CO., WILLIAM M.		Clay guns
57	BAILEY METER CO.	PRODUCT SPEC. P22-4 & E-22-4	Area meters
58	CLARK CONTROLLER CO., THE		D-c crane control
59	CONE-DRIVE GEARS, DIV. MICHIGAN TOOL CO.		Gearsets, gearmotors, speed reducers
60	DELAVAL STEAM TURBINE CO.	BULLETIN 0504	Centrifugal compressors
61	EDDYSTONE DIV., BALDWIN-LIMA-HAMILTON	BULLETIN 6002	Foundry bulletin
62	ELECTRIC MACHINERY MFG. CO.	E-M SYNCHRONIZER NO. 42	Synchronous motors
63	ELLIOTT CO.	BULLETIN PB 9000-1	Frame motors in frames up to the 620
64	ELLIOTT CO.	BULLETIN PB 9000-2	620 frame mill motor
65	ENTERPRISE CO., THE	BULLETIN 502	Friction saws
66	EUCLID ELECTRIC & MFG. CO., THE	BULLETIN 4400-4401	Manual and magnetic controller for cranes
67	FARVAL CO.	BULLETIN 26-S	Lubrication
68	FOXBORO CO., THE	AED SHEET 330-1	Automatic measurement and control of blast dew point
69	FRANTZ CO., INC., S. G.	BULLETIN PM-44	Magnetic separators
70	GARLOCK PACKING CO., THE	CATALOG 20	Klozure oil seals
71	HAGAN CHEMICALS & CONTROLS, INC.	BULLETIN MSP 149	Electronic receiver
72	HUNT & SON, INC., C. B.	BULLETIN NO. 571	Control valves
73	JOHNS-MANVILLE CORP.	BROCHURE IN-115A	Insulating fire brick
74	LECTROMELT FURNACE DIV., MCGRAW-EDISON CO.	CATALOG 10	Furnaces
75	LINK-BELT CO.	BOOK 2550	Roller bearings
76	MARLAND ONE-WAY CLUTCH CO.	ENGINEERING MANUAL NO. 56	Safe, dependable operations
77	NORTH AMERICAN MANUFACTURING CO., THE	BULLETIN 2.001	Web guide
78	NORTHERN ENGINEERING WORKS	BULLETIN W-101	Overhead electric traveling cranes
79	OKONITE CO., THE	BULLETINS IS-2117 & IS-1088	Insulated wires and cables
80	PACIFIC COAST ENGINEERING CO.	BROCHURE 4-D	Dual torque and float control
81	PLIBRICO CO.		Linings for industrial, foundry, and steel mill furnaces
82	POST-GLOVER ELECTRIC CO., THE	BULLETIN 410	Master switches
83	RELIANCE ELECTRIC AND ENGINEERING CO.	BULLETIN NO. D-2506	Packaged drives
84	REPUBLIC FLOW METERS CO.	BULLETIN NO. 806	Compact measuring instruments
85	ROCKWELL CO., W. S.	BULLETIN 440	Strip cleaning equipment
86	ROLLWAY BEARING CO., INC.		Cylindrical radial roller bearings
87	RUST-OLEUM CORP.		Rust preventive literature and color chart
88	SKF INDUSTRIES, INC.	CATALOG 447	Steel pillow blocks
89	TAYLOR CHAIN CO., INC., S. G.	BULLETIN 13	Alloy chain
90	TAYLOR INSTRUMENT COS.	BULLETIN NO. 98261	Instruments for indicating, recording and controlling temperature, pressure, flow, etc.
91	TREADWELL CO., INC., M. H.	BULLETIN 61	Air or steam operated cinder cars
92	UNITED STATES GRAPHITE CO., THE	B-56	Brushes
93	WESTINGHOUSE ELECTRIC CORP.	BOOKLET B-6548	Magnetic brakes
94	WATERBURY FARREL FOUNDRY & MACHINE CO.		Rolling mills and auxiliary equipment
95	YODER CO., THE		Cold-roll forming Pipe and tube making Slitting

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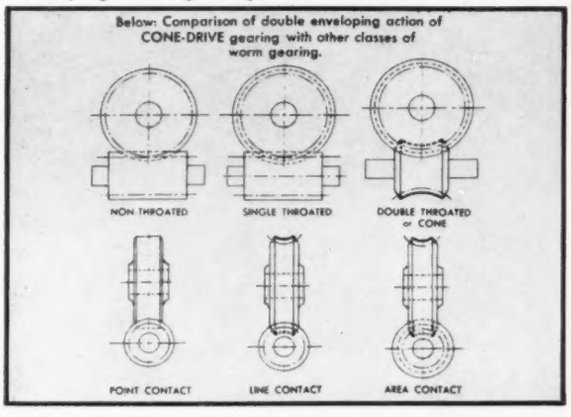
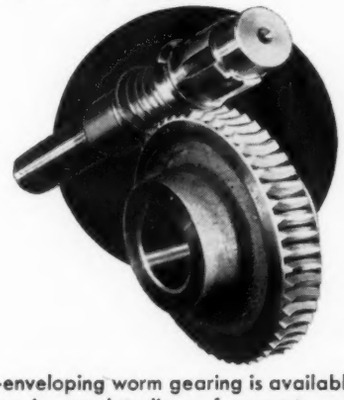
TEAR OUT AND MAIL IN FOR COMPLETE DATA

How to get the most out of Worm Gearing

If a right-angle drive is needed in your product and you require maximum capacity for your dollar, then the Cone-Drive double-enveloping type will give it to you. The sketch below shows the apparent advantages of Cone-Drive gearing as compared to other worm gear types. Double-enveloping worm gearing, the most modern and efficient

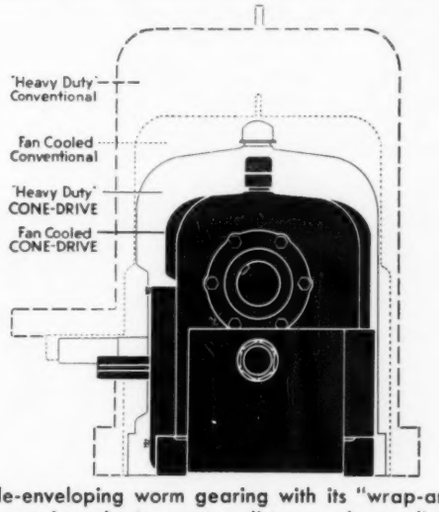

Below: Comparison of double enveloping action of CONE-DRIVE gearing with other classes of worm gearing.
NON THROATED
SINGLE THROATED
DOUBLE THROATED or CONE
POINT CONTACT
LINE CONTACT
AREA CONTACT

form, has straight-sided teeth in both worm and gear. Both elements of Cone-Drive are throated and envelop each other, providing a multiple tooth area contact. This means greater load-carrying capacity than is possible with any other type of worm gearing.

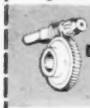


Double-enveloping worm gearing is available from Cone-Drive Gears in complete lines of gearsets, speed reducers and gearmotors. Gearsets are stocked in center distances from 2" thru 24", capable of handling loads from fractional to over 1600 horsepower. A complete line of mountings for gearsets is also stocked.

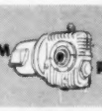
Speed reducers and gearmotors with Cone-Drive double-enveloping worm gearing are unusually compact and powerful drives that handle shock loads with ease. Yet, they provide power transmission smoother than that of hydraulic systems. Another advantage, unique to double-enveloping worm gearing, is their ability to regenerate themselves when wear occurs. Both worm and gear tend to reproduce the correct form in the other when wear occurs.



Double-enveloping worm gearing with its "wrap-around design" requires shorter center distances than cylindrical worm gearing to handle the same loads. As a result, Cone-Drive speed reducers have smaller housings with corresponding savings in weight and space. Bulky gear trains can often be replaced with a single Cone-Drive speed reducer or gearset.


DOUBLE-ENVELOPING WORM GEARSETS

DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS

DOUBLE REDUCTION WORM GEAR SPEED REDUCERS

DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS

CONE-DRIVE GEARS
DIVISION MICHIGAN TOOL COMPANY
7171 E. McNichols Road • Detroit 12, Michigan
Telephone: TWinbrook 1-3111

Please send me information on following:

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Company_____

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City_____ State_____

TEAR OUT AND MAIL IN FOR COMPLETE DATA

TEAR OUT AND MAIL IN FOR COMPLETE DATA

TEAR OUT AND MAIL IN FOR COMPLETE DATA

Aftercooler and Cyclone Separator designed for cleaner, dryer compressed air

The Adams Aftercooler and Cyclone Separator are designed to efficiently condense and remove water from compressed air and process gas. Condensed moisture and entrained dirt and oil are subsequently removed in a cyclone type separator. This unit is scientifically designed for maximum removal efficiency over a wide range of flow rates.

For normal use, units are available to cool gases to within 10° F of the temperature of the cooling water. Specially designed units are available to permit a 2° F approach to cooling water temperature, for application where low moisture content is critical.

Adams Aftercoolers and Separators are available from stock to handle 20 - 40,000 cfm with 10° cooling and 25 - 19,200 cfm where it is necessary to cool within 2°F of the cooling water. Special units can be supplied to suit an unlimited range of requirements. In all cases the maximum pressure loss at rated capacities is ½ psi.

This wide range of sizes enables the economical utilization of Adams Aftercoolers and Separators in virtually all industrial application. For further information on how R. P. Adams' units will solve your compressed air problems and save you money, write today for Bulletin 711. R. P. Adams Co., Inc., 223 East Park Drive, Buffalo 17, New York.

FILTER FERROUS GRIT

out of Lubricating Oil . . . and Hydraulic Fluid . . . Minimize Cost of Maintenance and Delays

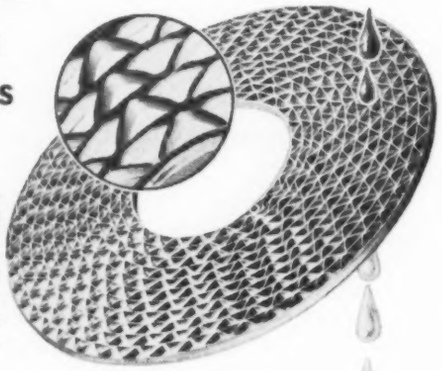
FERROFILTER®

Magnetic Separators

•

FERROFILTER GRID

(right) . . . one of a strongly magnetized stack with 100's or 1000's of feet of grid edges which catch and hold finest iron particles. Magnified inset shows ferrous grit collected on grid edges.



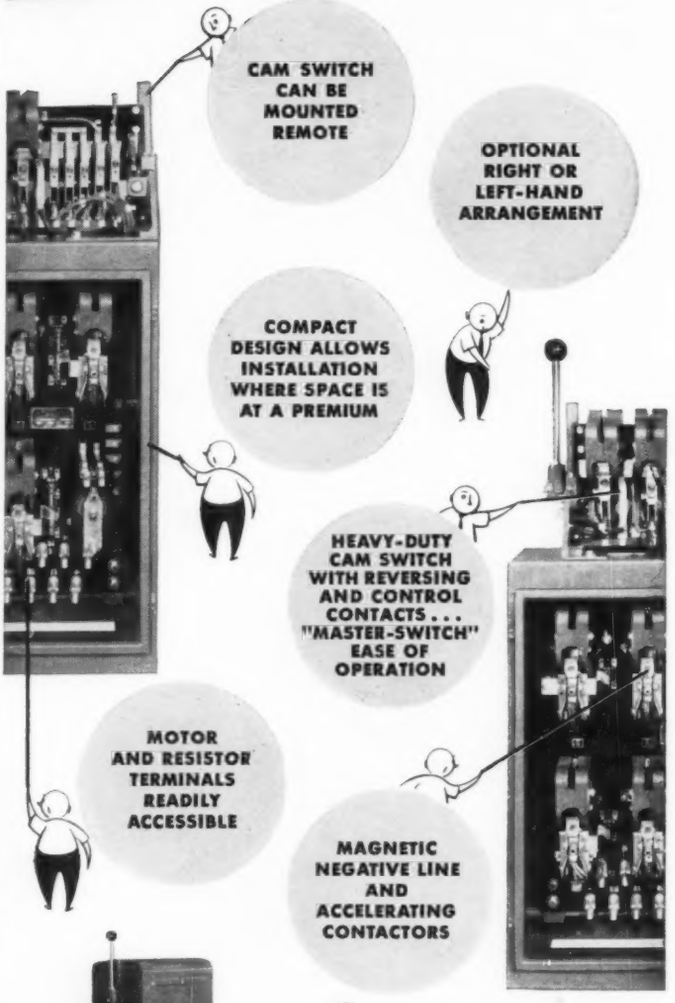
Send for
BULLETIN PM-44

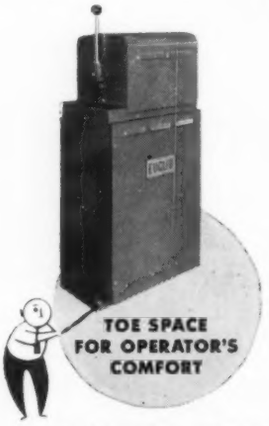
Model PQ-6 for 3" pipe line available with screwed or flanged connections. Other sizes from 3/8" to 8".

S. G. FRANTZ CO., Inc.
Brunswick Pike and Kline Ave.
P.O. Box 1138, Trenton 6, N.J.

NEW HEAVY-DUTY D-C MAN-NETIC CONTROLLERS*

COMBINATION MANUAL and MAGNETIC CONTROLLER FOR CRANES—CHARGING MACHINES—D-C CONTROL JOBS


CAM SWITCH CAN BE MOUNTED REMOTE
OPTIONAL RIGHT OR LEFT-HAND ARRANGEMENT
COMPACT DESIGN ALLOWS INSTALLATION WHERE SPACE IS AT A PREMIUM
HEAVY-DUTY CAM SWITCH WITH REVERSING AND CONTROL CONTACTS . . . "MASTER-SWITCH" EASE OF OPERATION
MOTOR AND RESISTOR TERMINALS READILY ACCESSIBLE
MAGNETIC NEGATIVE LINE AND ACCELERATING CONTACTORS



2 TYPES AVAILABLE: REVERSE-PLUGGING OR DYNAMIC - LOWERING

Provide four speed points, reversing, with all advantages of full-magnetic control. Manually-operated cam contacts are free of destructive arcing . . . extremely fast magnetic contactor action interrupts power circuit before cam-operated contacts are opened. EUCLID'S EXCLUSIVE "TIMELOK" feature offers maximum dependable acceleration timing without extra relays . . . permits unusually compact arrangement of the magnetic panel.

For more information, contact our representative in your area, or write or call THE EUCLID ELECTRIC & MFG. CO., MADISON, OHIO.
Ask for Bulletin 4400-4401.

*PATENT APPLIED FOR.

THE EUCLID ELECTRIC & MFG. CO.
MADISON, OHIO

THE EUCLID ELECTRIC
EUCLID
AND MFG CO. MADISON, OHIO

POOLE Flexible Couplings

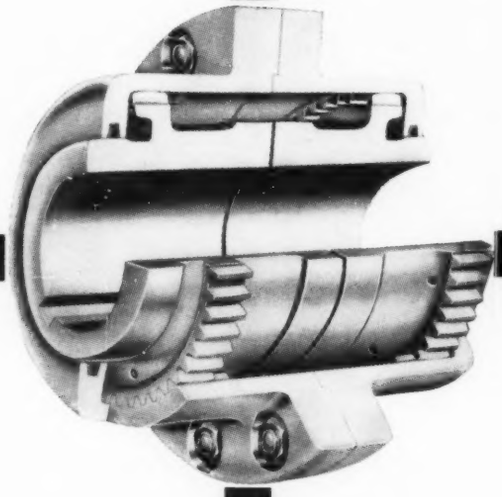
Look at these features—many of them exclusive with the patented POOLE:

Adjusts itself to all conditions, leaving its members free to float without strain to parts.

Geared type providing great strength, the highest efficiency of modern flexible coupling design.

No flexing materials to crystallize or break . . . No welded parts . . . Filled with oil, self-lubricating . . . Oil tight, dust tight . . . Permits free lateral float . . . Stronger than shafts it connects . . . Compensates for both off-set and angular misalignment.

Steel mill drives equipped with POOLE FLEXIBLE COUPLINGS.



Get the whole story from our handbook, "Flexible Couplings." A copy will be sent gladly without obligation.

the better

FLEXIBLE COUPLING

POOLE FOUNDRY & MACHINE COMPANY

1700 UNION AVE.

BALTIMORE 11, MD.

HE CAN "MEASURE" MORE PROFIT FOR YOU. This Dowell service engineer can measure the amount of scale he removes from a line, using the Dowell method of chemical cleaning. *This removed scale and sludge can also be measured in increased profit dollars for your company.*

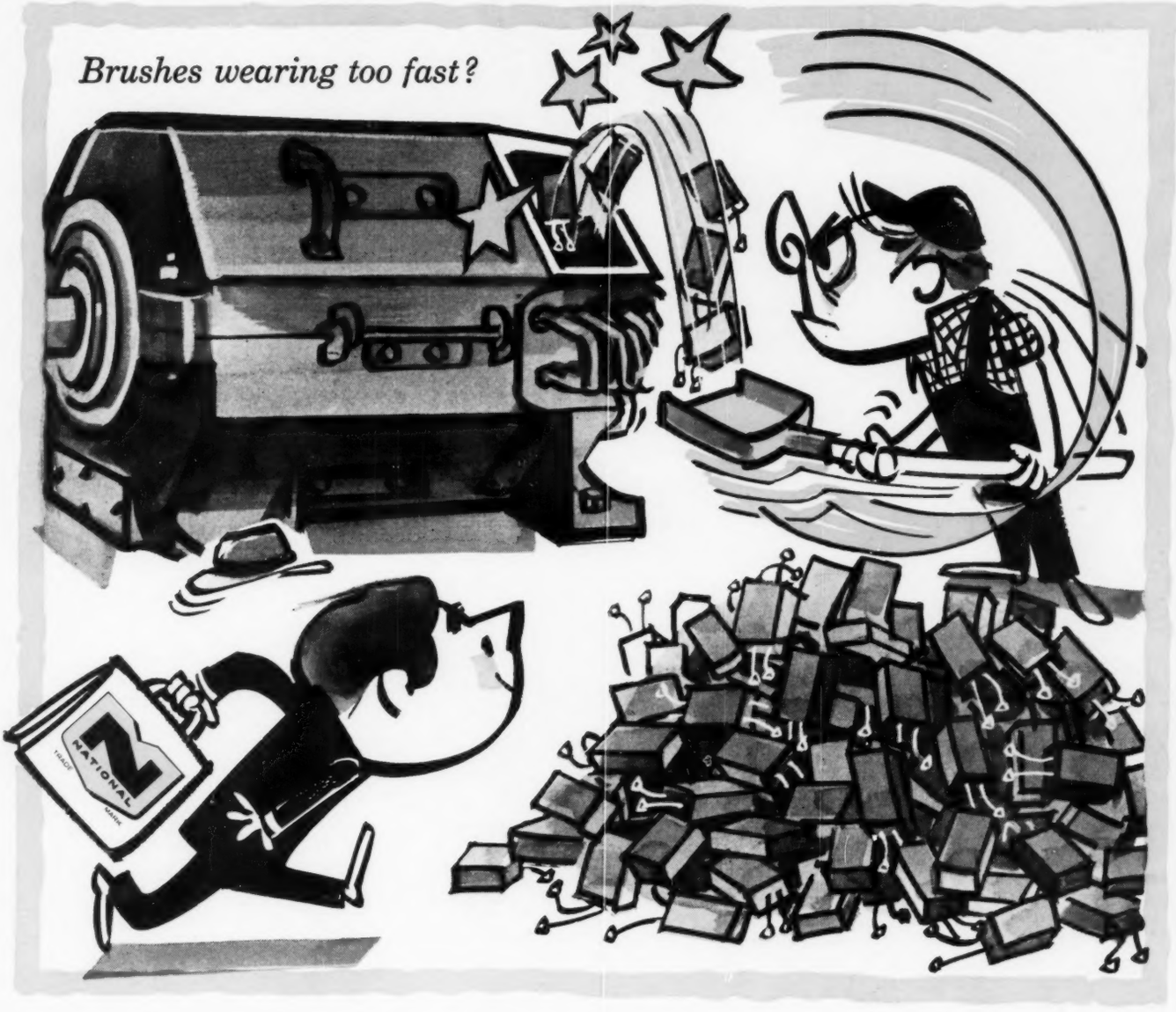
Example: Scale build-up in the main water supply line of a major Midwestern plant had reduced the "C" factor from 105 to 72. This situation became apparent just at the start of the peak season for the company. Management had a choice between laying an auxiliary line or trying to clean their present one. They decided to clean the line—but not the old-fashioned mechanical way. Time would not permit. Dowell was called in to do the job—chemically.

Dowell Service was fast—the job was done in three days. Dowell Service was effective—the "C" factor was increased to 92. Dowell Service was profitable for the customer—$71,000 was saved and the company's annual profit was protected.

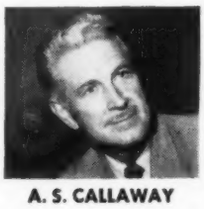
With Dowell Service you receive the benefits of more than fifteen years experience in chemical cleaning—plus a full line of equipment, chemicals, and trained personnel. You pay one charge, get an efficient job, handled by experienced people.

Your maintenance and operating engineers probably know about Dowell Service. Ask them for the facts. Decide for yourself about the additional profit possibilities to your company with Dowell Service working for you. DOWELL INCORPORATED—A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY. Headquarters and research center, Tulsa, Oklahoma, with 165 offices and stations to serve you.

Chemical cleaning service for industry DOWELL



These mill motors ate up brushes 'til the NATIONAL brush man stepped in!



A. S. CALLAWAY

The mill motors in this eastern steel mill were extra hard on brushes says "National" Carbon Brush Man, A. S. Callaway.

An unavoidable contaminant seemed to eat up every brush tried by the mill. Only one brush proved capable of withstanding this condition: "National" Brush Grade N-6. Naturally, the N-6, with its ability to withstand contaminants, is standard on these mill motors.

"Cal" Callaway and his fellow "National" Carbon Brush Men have been helping plants solve brush problems for years. Their experience and training—backed by National Carbon's *long term brush development*—make them top consultants on any brush problem.

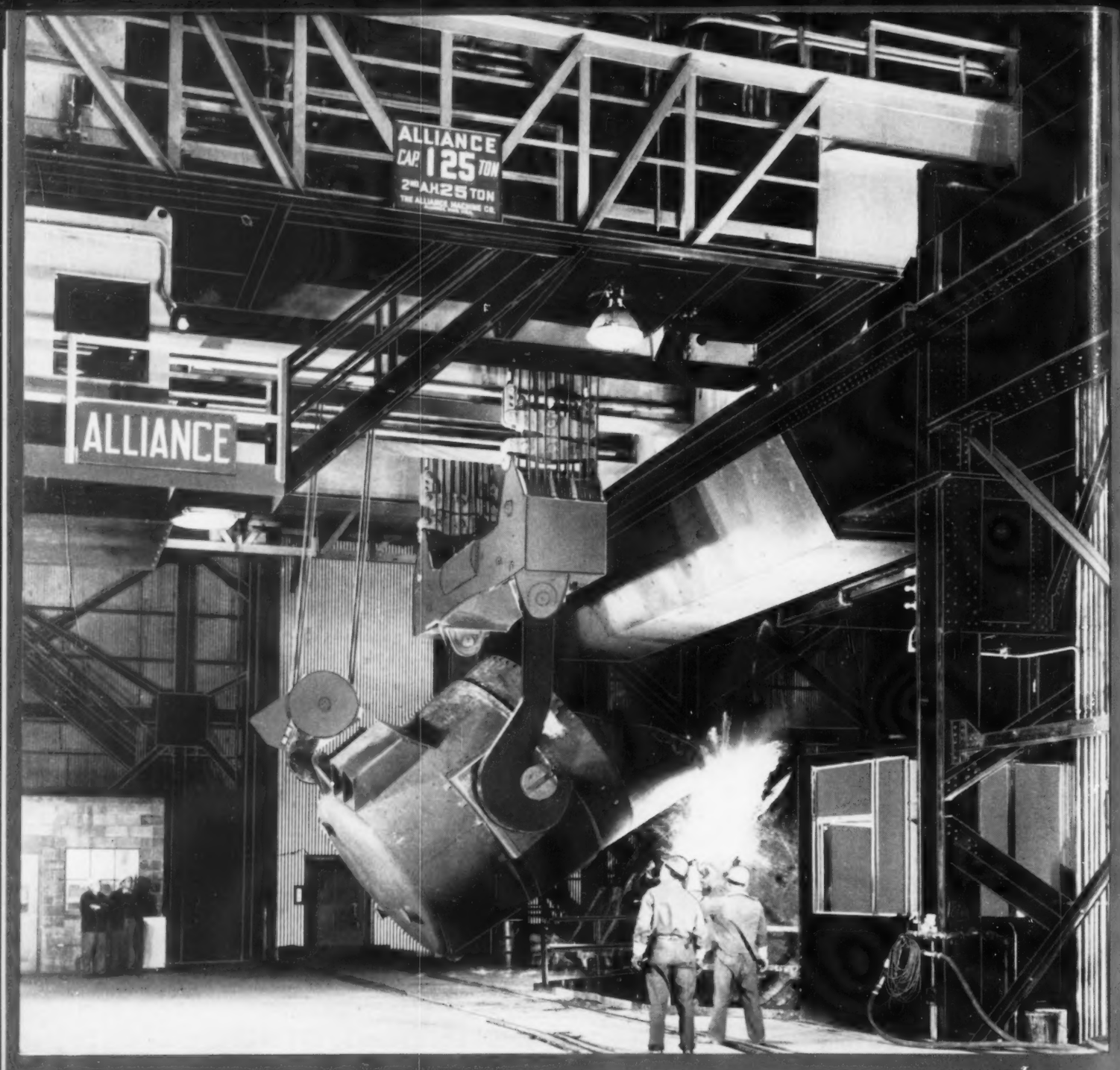
Call your "National" Brush Man today. Or write National Carbon Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

UNION CARBIDE

"National", "N" and Shield Device, and "Union Carbide" are registered trade-marks of Union Carbide Corporation

NATIONAL CARBON COMPANY • Division of Union Carbide Corporation • 30 East 42nd Street, New York 17, N. Y.

Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco. *In Canada:* Union Carbide Canada Limited, Toronto.



ALLIANCE CRANE SERVICES

JONES & LAUGHLIN BASIC OXYGEN FURNACES

A thorough study by Jones & Laughlin Steel Corporation pointed up the economic advantages of basic oxygen furnaces at its Aliquippa Works Division, where supplies of hot metal and scrap are plentiful. The two new furnaces have an annual rated capacity of 750,000 tons. They're the world's largest.

The Alliance 125-ton, 4-girder, interlocked drum, synchronized drive, ladle crane serving these furnaces was designed and built to meet furnace capacities. This type of crane was chosen by the Jones & Laughlin engineers because of its reliability and high factor of safety.

When considering new construction or replacements involving cranes, it will benefit you to consult with The Alliance Machine Company, who have specialized in steel mill cranes for over half a century.

Give Us The Runway And We'll Lift The World

THE *Alliance* MACHINE COMPANY

FOUNDED 1901 — MAIN OFFICE . ALLIANCE, OHIO

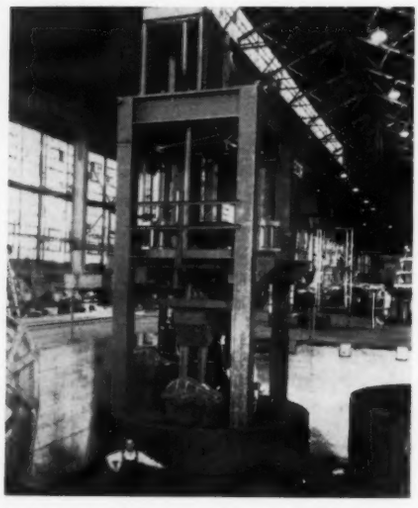
LADLE CRANES . GANTRY CRANES . FORGING MANIPULATORS . SOAKING PIT CRANES . STRIPPER CRANES . SLAB AND BILLET CHARGING MACHINES . OPEN HEARTH CHARGING MACHINES . SPECIAL MILL MACHINERY . STRUCTURAL FABRICATION . COKE PUSHERS

Equipment News...

POST CRANE

△ A huge smoke hood and oxygen lance handling crane, recently completed by the Pennsylvania Engineering Corp., is one of the key pieces of auxiliary equipment to be used with the new 80-ton capacity basic oxygen furnaces now being installed at the McLouth Steel Corp.'s Trenton, Mich., plant.

The crane is a package unit which carries the smoke hood and smoke-hood hoisting arrangement, lance



hoists, and lance clamping devices. The entire unit rotates to move the smoke hood from the top of the furnace when charging or pouring. All utilities, such as electric wiring, oxygen, cooling water, and compressed air are mounted on the crane. This wiring and piping is brought to a central point for the customer's plant source connections.

CIRCUIT BREAKER

△ A new low-capacity, sulphur-hexafluoride gas-filled circuit breaker with multiple reclosing abilities and designed for 46-kv systems is now available from the Westinghouse Electric Corp.

This circuit breaker has an interrupting rating of 250 mva and an interrupting time much better than its specified eight-cycle rating. The requested multiple reclosing duty cycle consists of three trips and two reclosures with lockout occurring after the third trip.

The new design features long mechanical and electrical life with minor and infrequent maintenance. The breaker, with its associated protective relaying, reclosing and control power equipment, is well adapted to economical installation in isolated locations and unattended substations.

The interrupter design and performance obtained with the circuit breaker is possible because of the unique arc interrupting and insulating characteristics of sulphur-hexafluoride. The breaker is filled with gas at the low pressure of 60 psig. On opening, thermal expansion of the gas, at the pressure break, forces the flow of SF_6 through the interrupting orifice as its moving contact is withdrawn, thereby performing the interrupting function.

The contact interrupter assembly is easily accessible and may be removed from any one-pole unit as a complete subassembly. A pin-clevis-type coupling for the drive shaft and a pair of spring-biased clamp-type fingers for making contact with the bushing facilitate reassembly.

The entire pole unit is made leak-tight by the use of synthetic rubber gasketing.

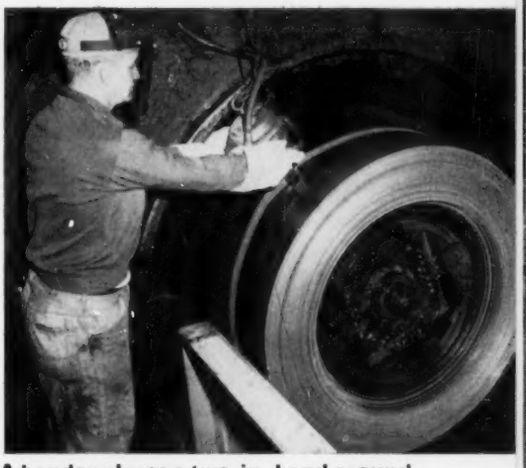
The operating mechanism is mechanically trip free, with a pneumatic shock absorber to cushion the opening stroke.

ASBESTOS GLOVES

△ Workmen at the Midland, Pa., plant of Crucible Steel Co. of America handle 1200 F steel with safety and ease in a banding operation through use of specially-developed asbestos gloves.

Using Mine Safety Appliance Co. Silvabestos gloves made of asbestos cloth treated with a special aluminum-resin coating, Midland employees have compiled a perfect safety mark—no lost time accidents—during the more than one year period use of this particular hand protection.

Speciality steels are rolled and coiled at the plant's 66-in. hot strip mill. Rolls are automatically positioned on a conveyor for the banding operation. This requires approximately two minutes, most of which is consumed by a manual banding procedure. Two men are employed on each of three shifts for banding.



A bander places a two-in. band around a newly-rolled coil of hot steel, which has a temperature of 1200 F. Wearing the gloves, which are asbestos treated with an aluminum-resin coating, he can touch the hot steel if necessary, without harm.

Although the men are not required to touch hot steel while banding coils, the gloves provide the ultimate in protection from burns in the event a hand or hands contact steel coils. The gloves also offer protection from heat radiating from coils as well as from the two-in. wide bands which reach a temperature of nearly 300 F as a result of contact with hot steel.

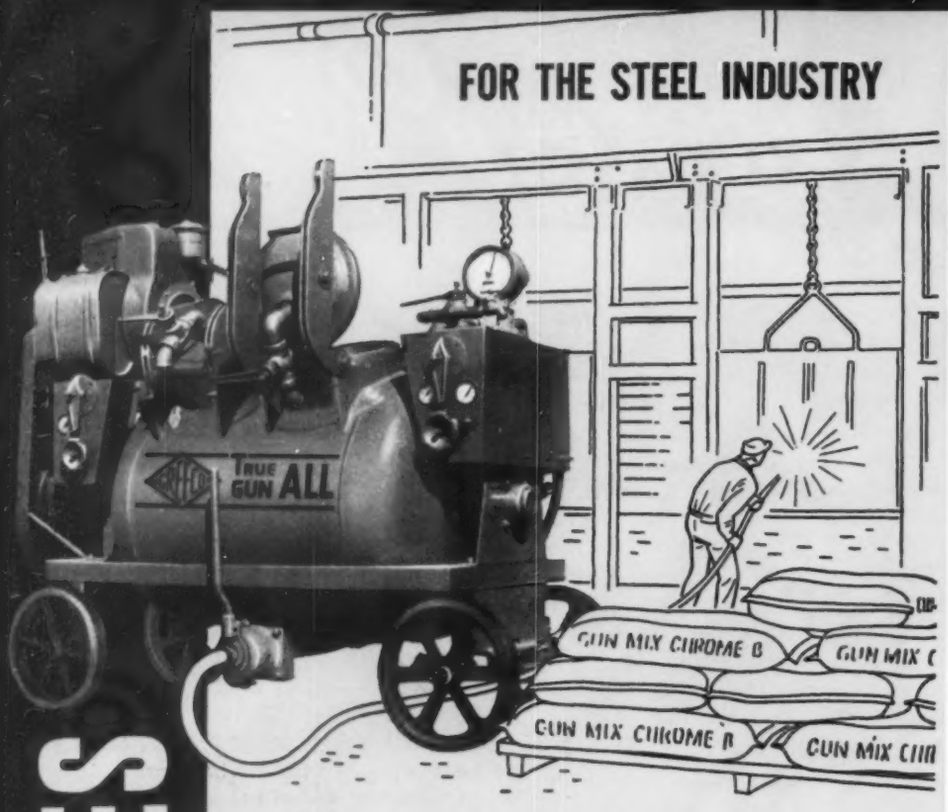
The company had provided banders with standard asbestos gloves for the operation. Plant safety officials did not believe these provided adequate protection. In an effort to improve protection before occurrence of a mishap Crucible began experimenting with several asbestos-type gloves. It was found that while wearing the light, comfortable but highly heat resistant Silvabestos Gloves, men could actually touch the glowing steel without sustaining burns.

TRANSFORMERS

△ The manufacture of its own sealed dry-type transformers now

GENERAL REFRACTORIES

FOR THE STEEL INDUSTRY



A BETTER WAY TO PLACE ALL REFRACTORY MIXES...

Now offered as a revolutionary advance in the field of pneumatic refractories application, the GREFCO TRUE GUN-ALL is a *true* all-purpose refractory gun handling all types of bulk refractory products.

In the steel industry, the GREFCO TRUE GUN-ALL allows *faster*, easier and more economical placement of GREFCO refractory products:

CHROME GUN MIXES—*for open hearth back walls*
MAGNESITE GUN MIXES—*for tap holes and general patching*
HIGH DUTY FIRECLAY MIXES—*for hot patching high duty clay brick*
HIGH ALUMINA MIXES—*for hot patching where high alumina is desired*
COMPLETE RANGE OF CASTABLES—*for soaking pit covers, blast furnace piping and other applications*

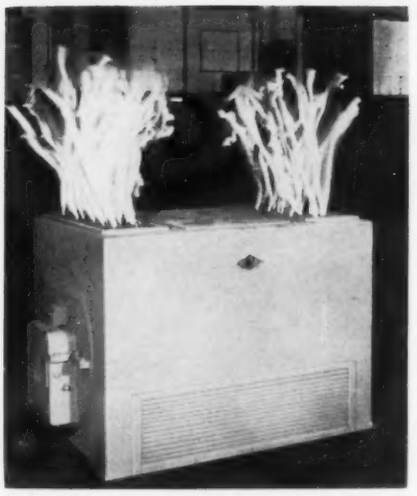
In the GREFCO TRUE GUN-ALL, water is added to the refractory *in the mixer*. No guesswork on moisture content. Minimum of rebound loss. Handles complete range of materials—coarse or fine grind—very wet or extremely dry mixes—light weight or heavy aggregates. One machine for all applications.

GREFCO

GENERAL REFRACTORIES COMPANY
Philadelphia 2, Pa.

Write for information on gun and gun mixes.

FEED PUMP MOTOR



Boiler feed pump motor, a product of Electric Machinery Mfg. Co., features an interesting application of motor ventilation. The air being discharged from this motor is being blown straight up as can be seen by the streamers. Intake air goes through large louvers at the bottom. Motor is built in modern box type construction so that power plant personnel can see over the motor without difficulty. The use of vertical ventilation enables placing the motors close to each other without trading or recirculating air. Motor shown is of the induction type running at 3600 rpm. It is typical of the trend toward higher steam pressures and temperatures in power plants which require high speed and larger motors capable of operating at high temperatures, for the boiler feed pumps.

enables I-T-E Circuit Breaker Co., to provide all major components—switchgear and transformers—for its entire line of unit substations.

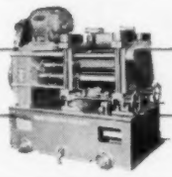
Formerly, only liquid-filled and ventilated dry-type transformers were made by I-T-E. The sealed dry-types had been purchased from outside suppliers.

The new transformers incorporate advanced design features, such as solid copper secondaries and a unique system for clamping coils to core assemblies, to produce a rugged, long-life unit.

In addition, shorter lead time on delivery and simplified servicing by the one company are expected to result from the design and manufacture of all major substation components by I-T-E.

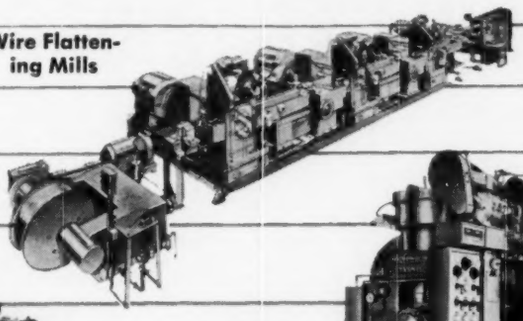
Solid copper secondaries provide exceptional strength to meet the

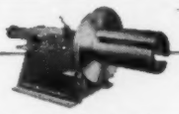
(*Please turn to page 212*)



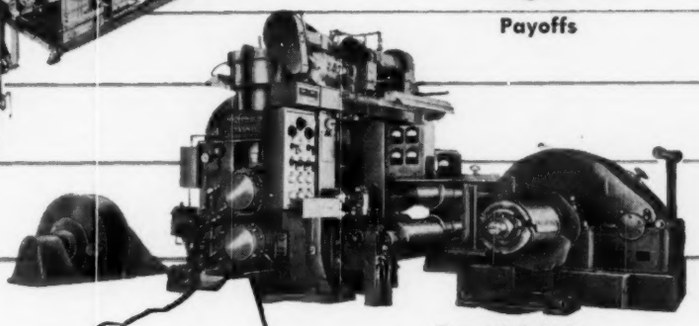
Coilers

Wire Flattening Mills

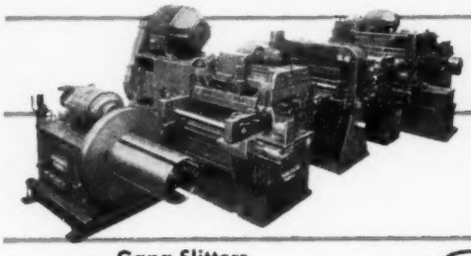




Payoffs



Two High Strip Rolling Mills

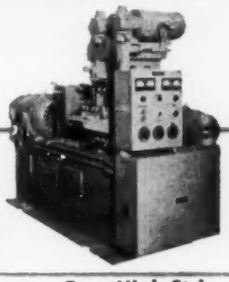


Gang Slitters

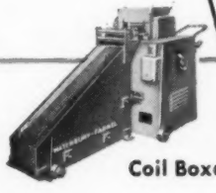
MEMO

Re Rolling Mill Modernization

Look Into Latest Waterbury Farrel Mill Machinery

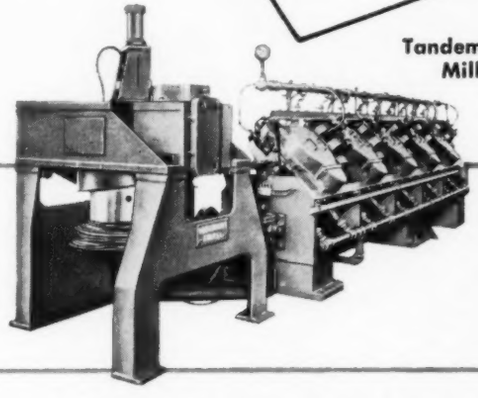


Four High Strip Rolling Mills

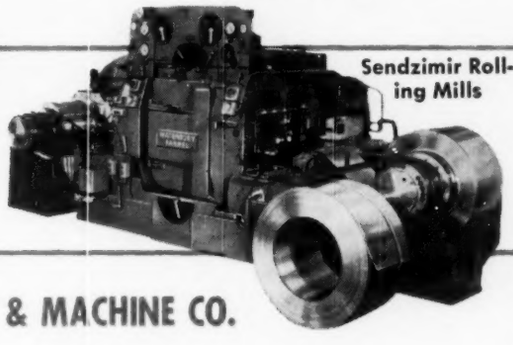


Coil Boxes

NEW, 48 PAGE MILL MACHINERY CATALOG.
Gives a complete picture of the various types of mills and auxiliary equipment built by Waterbury Farrel. Send for your copy, today.



Tandem Rod Mills



Sendzimir Rolling Mills

ROLLING MILL EQUIPMENT

Four-High Rolling Mills
Gang Slitters
Grading Mills
Mint Mills
Sendzimir Rolling Mills
Special Rolling Mills
Two-High Rolling Mills

AUXILIARY EQUIPMENT

Coil Boxes
Coilers
Coil Lifts and Transfers
Belt Wrappers
Edgers
Handling Equipment
Payoffs
Straighteners
Winders

ROD AND TUBE MILL EQUIPMENT

Draw Benches
Tandem Rod Mills
Three-High Rod Mills
Two-High Rod Mills

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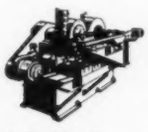
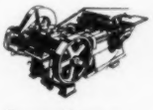
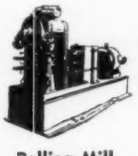


Bolt, Nut & Screw Machinery



Power Presses

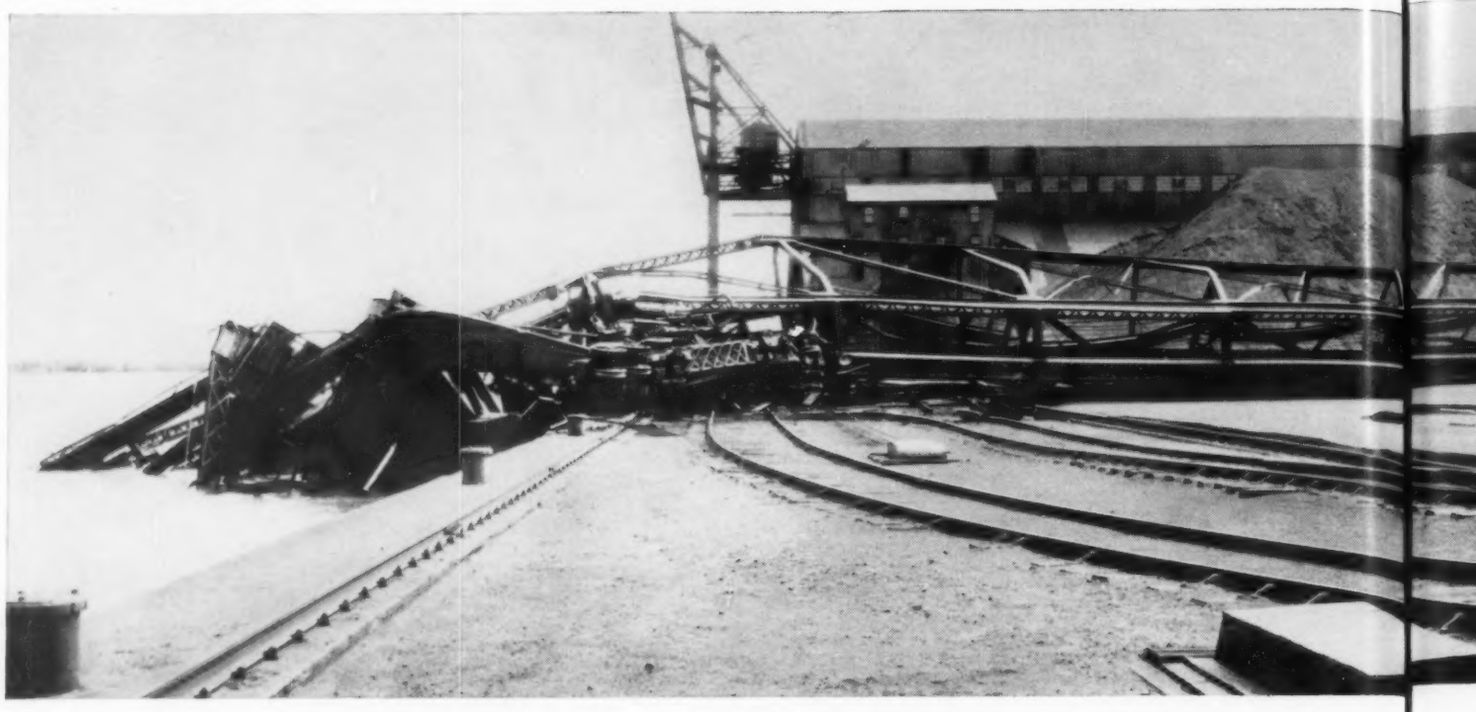


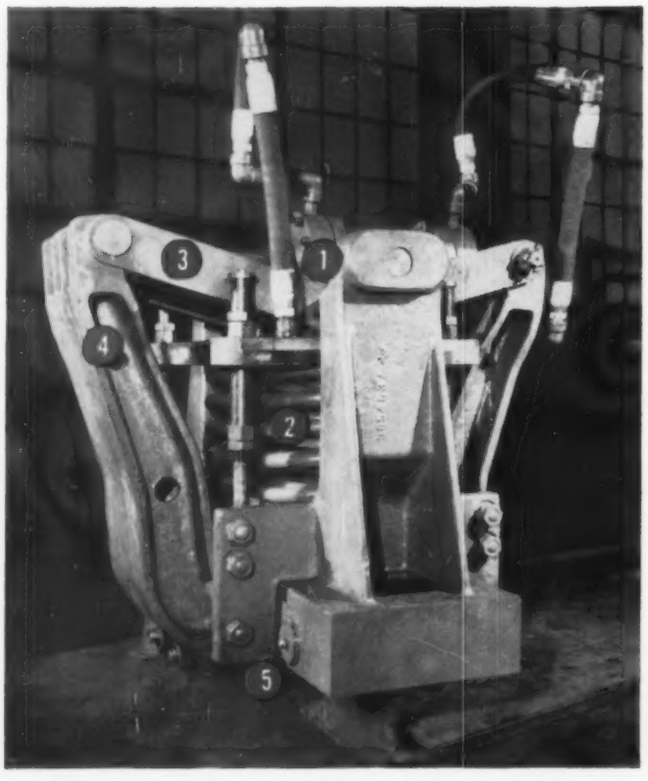
Rolling Mill Machinery

Wire Mill Equipment

Sendzimir Mills & Special Machinery

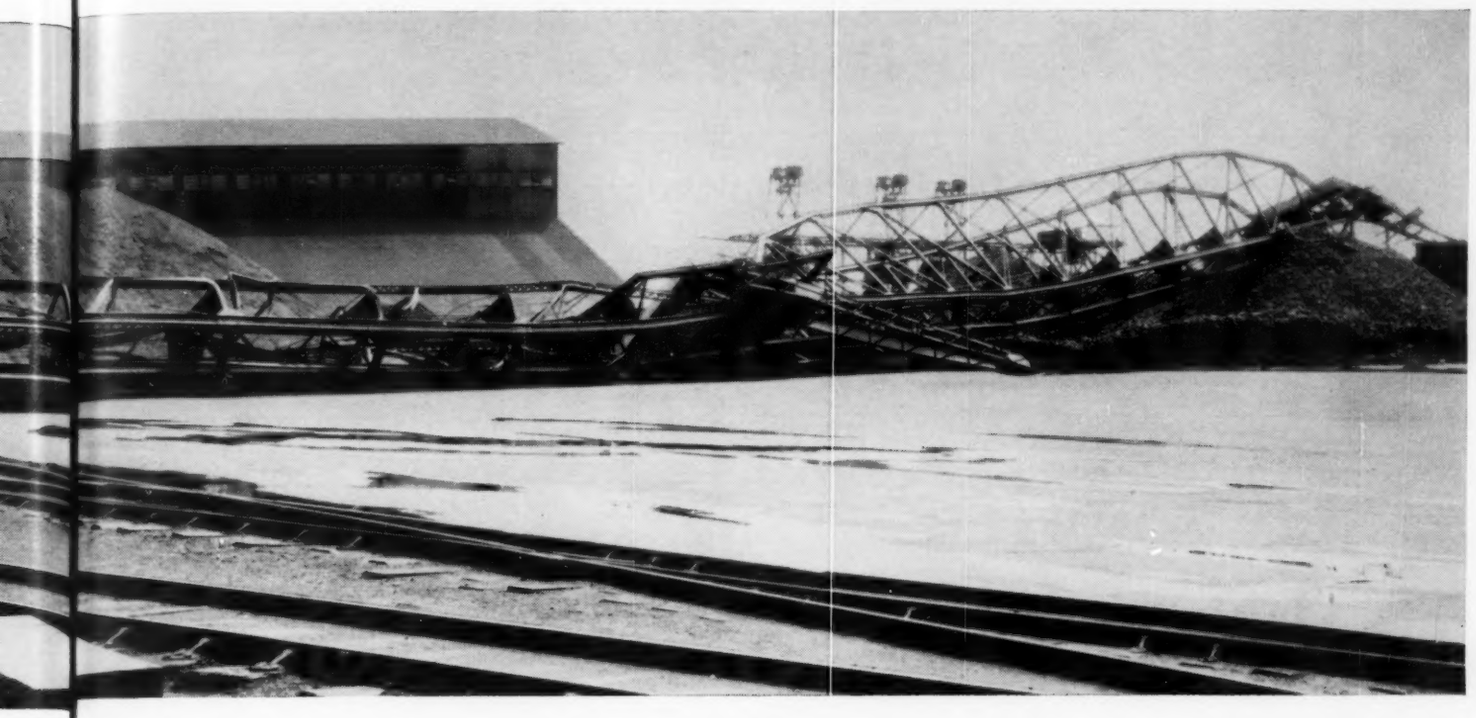
HOW MUCH WILL YOUR ORE BRIDGE BE





During bridge travel, hydraulic cylinder (**1**) keeps heavy helical springs (**2**) compressed, holding clamp in released position. When winds reach a predetermined level, or when travel motors are not operating, pressure is automatically released from the cylinder. This allows the springs to force the toggle arms (**3**) upward, spreading lever arms (**4**) and forcing jaws (**5**) against the railhead at tremendous pressure. Gripping jaws are easily and quickly replaced by removing two bolts (**6**) from each jaw. Clamp assembly rolls along rail on hardened-steel wheels (**7**). Jaws never rub against railhead.

WORTH AFTER THE NEXT WIND STORM?



NEW DRAVO *GALE-GUARD* RAIL CLAMPS PREVENT SLIPPAGE IN 100 MPH WINDS

Almost every year high winds make a million dollar junk pile out of some busy ore bridge. Dravo's new *Gale-Guard* rail clamps can keep this from happening to you. Here are facts you should know immediately about this new rail clamp design.

HOLDING POWER: The new *Gale-Guard* clamps will hold a bridge or unloader stationary in winds in excess of 100 mph. Special replaceable jaws with hardened-steel rail-gripping teeth assure maximum holding power.

AUTOMATIC OPERATION: Controlled by an anemometer, *Gale-Guard* clamps automatically lock the structure to the rails if winds exceed a predetermined velocity.

APPLICATION: Standard on all Dravo ore bridges and unloaders, *Gale-Guard* rail clamps are also available for quick, economical installation on existing equipment.

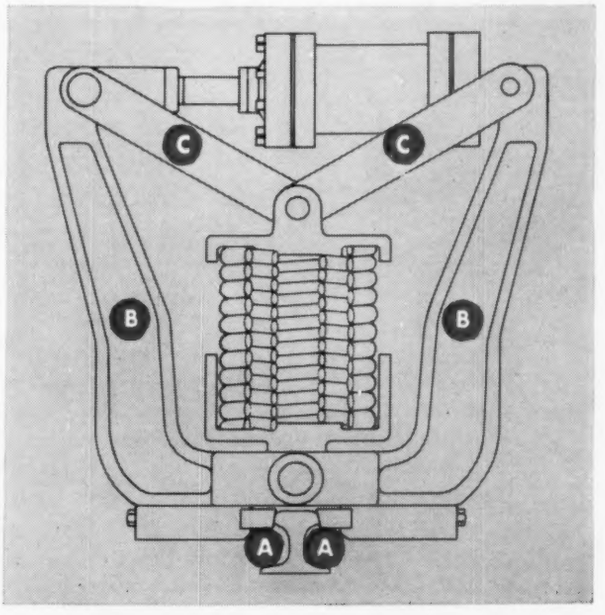
NO ADJUSTMENTS NEEDED: *Gale-Guard* rail clamps automatically increase holding pressure to compensate for long-term jaw wear and railhead variation. Operator adjustment is never necessary. See drawing at right.

MAXIMUM JAW WEAR: *Gale-Guard* rail clamps roll along the rail on hardened-steel wheels. This means that the open jaws never rub against the railhead during travel.

LOW, EASY MAINTENANCE: *Gale-Guard* rail clamps need little maintenance other than occasional jaw replacement. This is simple since each jaw can be replaced in a matter of minutes by loosening two easy-to-get-at bolts.

SAFETY INTERLOCK: Clamps are automatically set at all times except when the structure's travel motors are operating. In case of power failure, the clamps automatically lock the bridge or unloader to the rails.

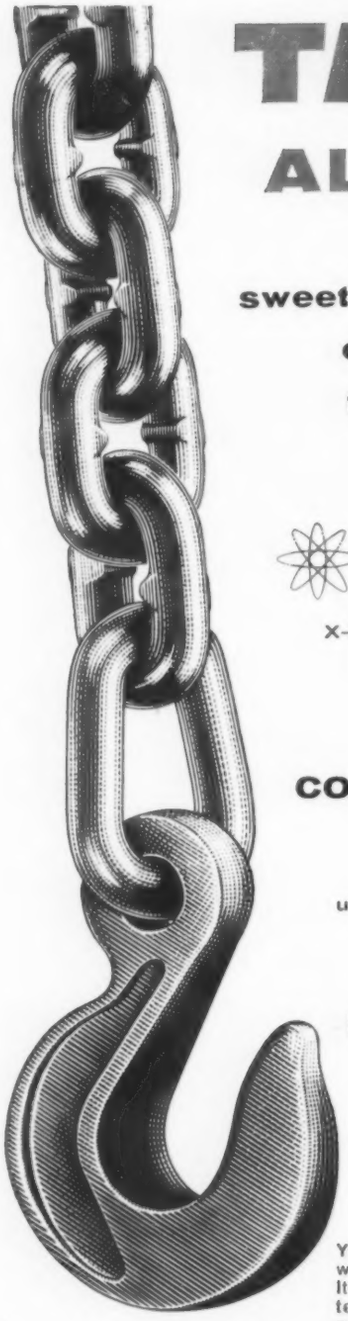
PRICE: Because of the outstanding features and high-quality workmanship of the new *Gale-Guard* clamps, cost may be slightly higher than other devices.



Gale-Guard rail clamps automatically compensate for jaw wear or railhead variations. As jaws (**A**) wear, spread of lever arms (**B**) increases. This causes the angle of the toggle arms (**C**) to flatten, thus increasing jaw pressure at the railhead.

FOR MORE INFORMATION:
Contact Dravo Corporation, Pittsburgh 25, Pa.

DRAVO
CORPORATION



TM Triple-Safe ALLOY CHAIN

sweet music for safety-minded, cost-conscious men throughout industry

GAMMA RAY QUALITY CONTROL!

X-Ray type testing of master, joiner and end links assures safe, trouble-free welds.

CONTROLLED ATMOSPHERE HEAT-TREATING

on all popular sizes provides uniformity throughout the sling assembly.

EXCLUSIVE PATENTED TAYCO HOOKS!

I-Beam type design plus alloy steel construction mean extra safety!

Pat. No. 2,646,306

REGISTERED!

You get a certificate of test with every TM Alloy Chain. It bears the chain's guarantee . . . proof test . . . serial number for easy identification.

CERTIFICATE OF TEST

You can boost your safety records up and pull your chain costs down with TM *Triple-Safe* Alloy Chain. Gamma Ray Quality Control, Controlled Atmosphere Heat-Treating and patented Tayco Hooks make it *triple-safe.* And Taylor's special analysis Alloy Steel makes it stronger . . . more resistant to shock, work-hardness and grain-growth! Lasts many times longer! Get *all* the facts—contact your Distributor or write for Bulletin 13 right away.

Chain is our specialty, not our sideline!

TAYLOR MADE A GREAT NAME IN Chain SINCE 1873

Contact your nearest Distributor or write
S. G. TAYLOR CHAIN CO., INC.
Plants: Box 509, Hammond, Indiana
3505 Smallman St., Pittsburgh 1, Pa.

(*Continued from page 208*)

electrical and mechanical stresses produced by short circuits and other overload conditions.

The clamping arrangement results in a transformer assembly which is resistant to the mechanical shock occurring during short circuits.

Service and maintenance are cut to an absolute minimum through use of sealed dry-type units.

The sealed type unit, enclosed in a shell filled with an inert gas, requires no attention after installation. Class H insulation maintains excellent dielectric properties at the higher operating temperature which prevail within a sealed enclosure.

The ventilated unit can operate unattended except for the need for periodically blowing out dust that collects on the core and coil assembly. Class H insulation also is available in the ventilated transformer to provide greater overload capacity and resistance to moisture while greatly reducing the need for periodic maintenance.

The unit substations are available for distribution applications in a range of 300-kva through 2000-kva. Primary voltages available range from 2400 volts through 15-kv; standard secondary voltages from 120 through 600 volts are available.

PORTABLE WELDER

△ Now available from Wall Colmonoy Corp. is a new portable welding machine for semi-automatic application of hard-facing wire.

The new machine features a long (14-ft) flexible shaft for greater working range from one position, and a double-range arc length control circuit for greater operating range and better welding control. For simplified maintenance and service, plug-in circuit construction is utilized. The control panel, for example, is installed as a unit; is quickly and easily removed by loosening four screws. Operating circuits plug into the control panel; are readily disconnected for safety and convenience.

A remote control "inch" button, conveniently located on the electrode holder, is also available on the welder. This feature eliminates need for leaving the work to advance the electrode as required during arcing.

Two simple connections (electrode

News and Notes on...

Good Packing Practice

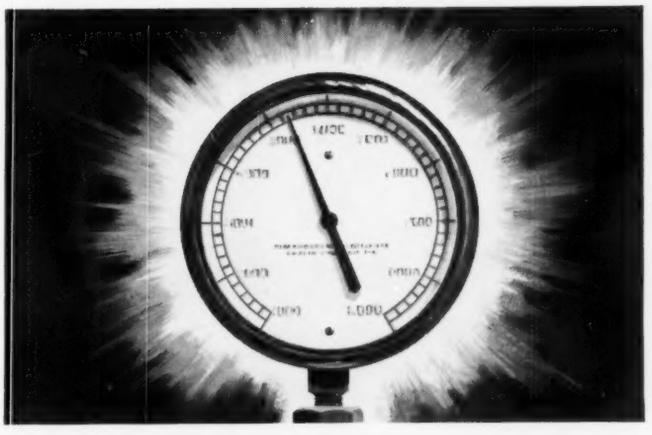
JOHNS-MANVILLE JM PRODUCTS

Maintenance and Design Hints from Johns-Manville Packings and Textiles Dept.

Subject of the month: High Operating Pressures

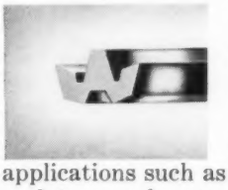
Problem:

How can today's process industries and equipment meet the requirements to stay "on stream" in the face of increasing burdens placed on packings by higher operating pressures?



Condition 1

FOR RODS AND PLUNGERS WORKING AT 2,000 TO 3,000 PSI, MOULDED UNEEPAC® RINGS



Wherever reciprocating machinery calls for a minimum of downtime and maximum efficiency in the face of high pressures, Uneepac rings have proved universally dependable. Manufacturer's life tests and applications such as hydraulic presses, pump rods, accumulators, and compressors show Uneepac takes hundreds of thousands of cycles without replacement. Quality materials and carefully engineered design and construction are the key to Uneepac's success in thousands of high-pressure applications. For information on J-M Moulded Packings, write for new, free booklet, PK-126A.

Condition 2

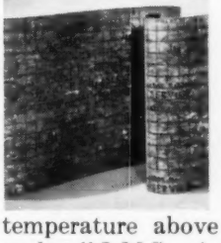
FOR VALVES OPERATING AT PRESSURES TO 5,000 PSI

Tough J-M Chempac® Teflon®-asbestos valve stem packing, Style 2011, combines the heat resistance of asbestos and the corrosion resistance of Teflon. Specify this long-life packing for high-pressure applications to 5,000 psi at temperatures to 500F. In some special cases it has withstood 50,000 psi. You'll find complete details on Johns-Manville's broad line of Chempac Packings in booklet PK-124A. Write for your copy today.

For information on any Johns-Manville Packings and Gaskets, write Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario.

Condition 3

SHEET GASKETS FOR PRESSURES TO 1200 PSI (A QUICK RULE OF THUMB)



To determine whether a job calls for a sheet gasket or a metallic gasket, try the following rule of thumb: "Multiply operating pressure (psi) by operating temperature (°F). If the product does not exceed 250,000, J-M Service® Sheet gaskets can be used. Pressures above 1200 psi or temperature above 850°F, usually call for a metallic gasket." J-M Service Sheet No. 60 effectively seals against heat, cold, water, steam, oils, mild acids and caustics.

Condition 4

FOR STANDARD FLANGE APPLICATIONS TO 6,000 PSI

When you run into the problem of extreme pressures and extreme pressure variations, specify Spirotallic® spiral-wound, metal-asbestos Goetze gaskets. Offering high mechanical strength and resilience, Spirotallic Gaskets seat readily under light bolting. Their special interlocking design and stainless steel construction effect and maintain a tight seal in the face of wide temperature and pressure variations. Write for booklet PK-35A.

JOHNS-MANVILLE

100 YEARS OF QUALITY PRODUCTS . . . 1858-1958

lead to machine and machine lead to ground) complete the hook-up requirements for putting the new unit in operation. The welder operates from any welding machine 300 amps or larger. All power comes from the welding machine; no extra power is needed. Power source may be ac-dc rectifier, motor-generator, gas drive or constant potential machine. No alterations are required when switching from alternating to direct current.

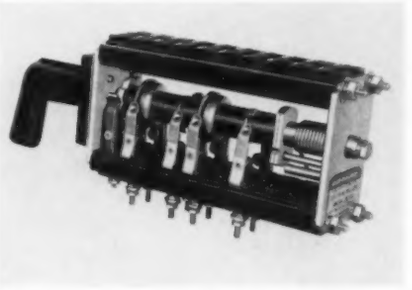
The new machine is mounted on four wheels for complete portability. The front wheels are full 360-deg caster type.

CONTROL SWITCH

△ Announced by Allis-Chalmers Manufacturing Co., is a newly-designed, heavy-duty control switch (Type 210 MD) recommended for master switch service in steel mills, processing plants, copper, brass and aluminum mills and other similar heavy industries.

New design components include: a heavy duty return spring easily accessible from the rear of the switch; bearings of case hardened beryllium copper plated with nickel; contact fingers of stainless steel; contact segments of beryllium copper plated with nickel, all for longer life.

The switches feature long life and low maintenance and are avail-



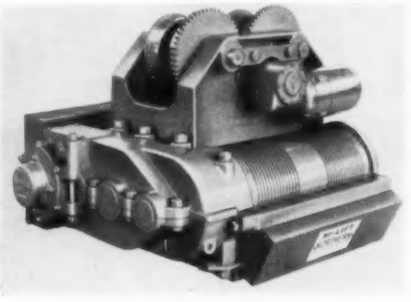
able in countless combinations of handles, colored or black, contact developments, spring return or non-return, key handles, pull out, etc. They are arranged for pulpit, bench-board, switchgear or control cabinet mounting.

These switches have the same general external appearance and features as Allis-Chalmers instrument control switch line (Type 210) available for general switchboard and switchgear work.

HOISTS

△ Northern Engineering Works announces that Northern Hi-Lift hoists, in all models from two through 15 tons capacity, with all their heavy duty, rugged features, including the same low headroom, are now also available with a new, inexpensive trolley drive designed for moderate speeds, and for single or variable speed control.

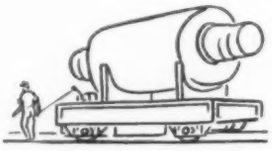
A worm drive provides smooth, quiet and trouble-free operation.



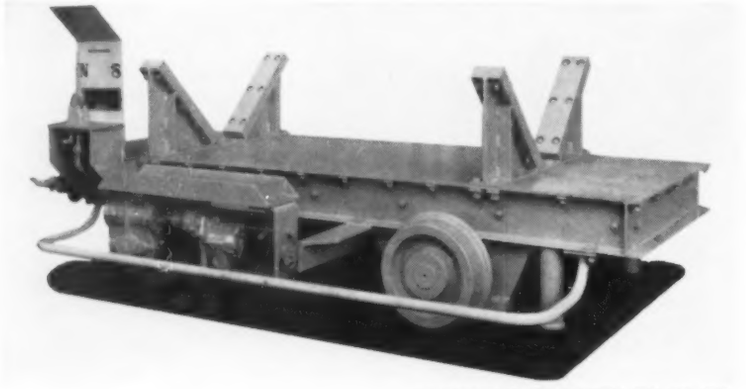
Compact design and arrangement allow maximum approaches with minimum space requirement.

These two-motor hoists are available for a-c or d-c current, and are built with standard or fluid coupling drives.

built to suit your LOADS AND SCHEDULES



ATLAS SAFETY-TYPE TRANSFERS



14-TON AIR-OPERATED ON 80 PSI

Atlas will engineer load-carrying transfer cars to meet your plant's specific need, capacity and power-wise.

Safety-type, single-lever "Walk Along" models; or platform type (operator rides).

Optional power, diesel or gas-electric, storage battery, air, or cable reel. Also, remote control with no trailing cable.

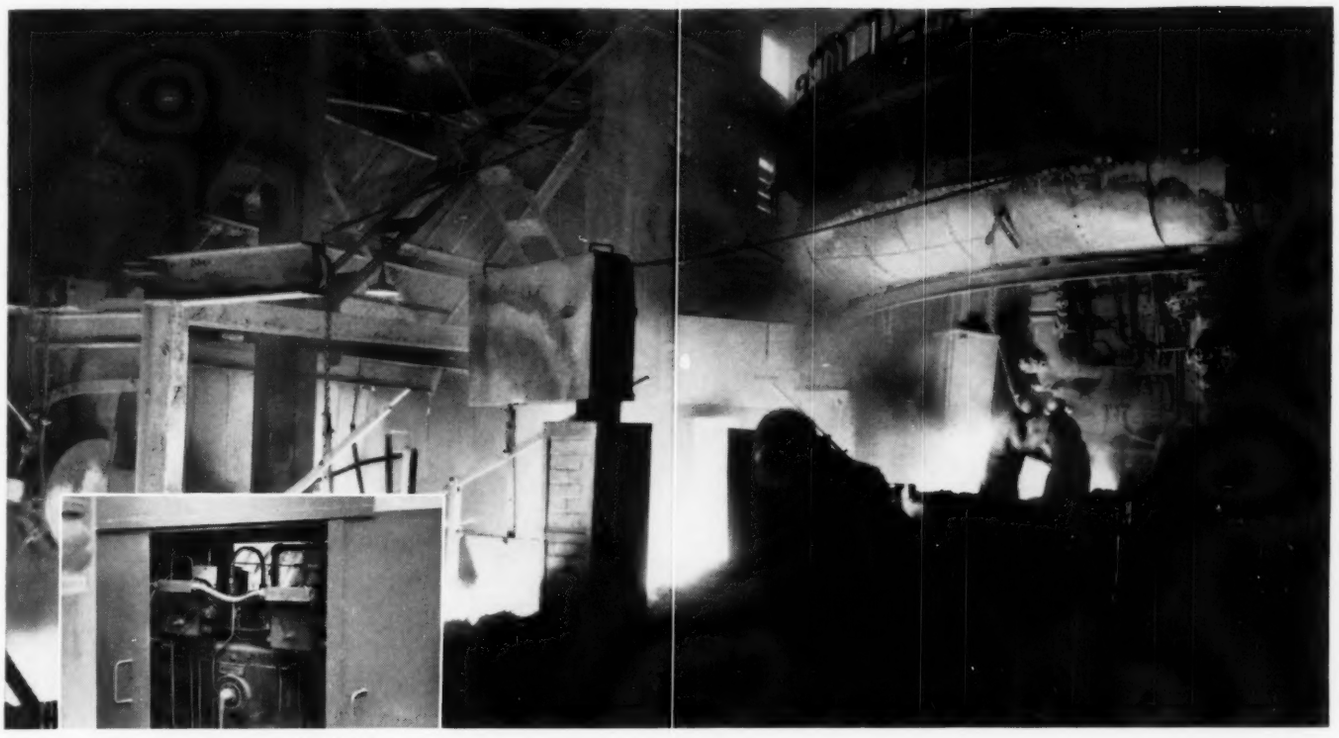
Request Bulletin 1283 for the Trained Dog Story.

ATLAS CAR & MFG. CO.
1100 IVANHOE ROAD
CLEVELAND 10, OHIO

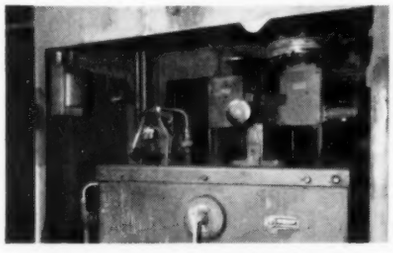
ENGINEERS AND MANUFACTURERS SINCE 1896

From top to bottom on Inland Steel's blast furnaces...

ASKANIA AUTOMATIC CONTROLS



High top pressure controls help No. 6 maintain record production.



Askania automatic control equipment for gas washer water level.

Askania self-contained Unit Regulator for hot blast stove combustion control.

Almost everywhere you look on Blast Furnace No. 6—and the other seven, too—at Inland Steel Company's Indiana Harbor Works at East Chicago, Indiana, you'll find Askania *hydraulic* automatic control equipment. From high top pressure controls down to stove burner controls . . . from gas washer water level controls to blast furnace blower controls . . . rugged Askania equipment is on the job.

Designed and built by Arthur G. McKee & Company, No. 6 was blown in on November 16, 1942. Early in 1957, Askania high top pressure control was added; since then No. 6 has been surpassing even its previous records of iron production.

These blast furnace controls are examples of Askania straight-line control engineering at work—simple, straightforward equipment and systems—*controls for steel.*

Specify Askania controls for every furnace, coke oven, gas mixing, blower control, and strip guiding application. Call your local Askania office, or write direct to Chicago for your copy of the complete, informative Askania catalog.

STRAIGHT-LINE AUTOMATIC CONTROLS FOR INDUSTRY

•

SYSTEMS ENGINEERING

•

VALVE ACTUATORS AND CYLINDERS

•

HYDRAULIC POWER AND PRECISION FOR AUTOMATIC CONTROL

ASKANIA

GENERAL PRECISION EQUIPMENT CORPORATION

ASKANIA REGULATOR COMPANY · **246 East Ontario Street** · **Chicago 11, Illinois**

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

ROTARY KNIVES

△ Cowles Tool Co. has designed and introduced a new line of tungsten carbide slitting and trimming knives.

These knives feature the extremely hard cutting edges needed to produce straight and true edges with minimum burr when slitting or trimming light gages of silicon or high or low carbon steel. The knives are manufactured in two styles: of solid tungsten; or, with a circular tungsten carbide cutting edge accurately and securely mounted in a tough heat-treated alloy steel body.

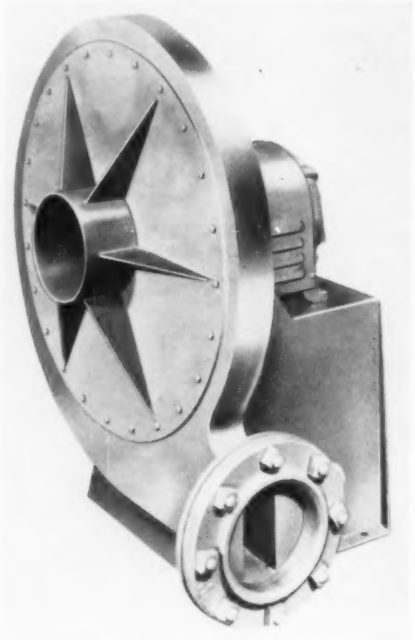
They are available in a wide range of sizes to meet any slitting or trimming requirement.

BLOWERS

△ A new series of turbo-pressure blowers, designed to efficiently furnish air at high pressures for use with oil and gas burners on industrial furnaces, scale blowing and air curtains, has been announced by the Chicago Blower Corp.

The blowers are designed to maintain a constant pressure while supplying varying volumes of air. The blowers characteristically demonstrate a power-consumption curve closely proportional to the amount of air used or delivered.

Designed for high speed to reduce space requirements to a minimum



for a given duty, the rotating elements of the blowers are of light weight, high strength construction as a safety factor and to help maintain high operating efficiency.

Construction of the blowers is of one type, regardless of size or whether for pressures from 4 oz to 24 oz. The blowers must be operated at 3450 rpm and require 60 cycle current.

TROLLEY SYSTEM

△ An electrical trolley system which is said to provide 100 per cent safety at all times has been introduced by U-S Electric Mfg. Co. Design also is intended to eliminate need for maintenance resulting from foreign matter coming in contact with any part of the system.

The system is a departure from conventional systems in that it will carry high amperages required by heavy-duty cranes and similar equipment. Components include an extruded, hard-drawn copper conductor bus; a sliding collector shoe of self-lubricating alloy copper; and a flexible protective sheath covering both bus and shoe. In crane bridge electrifications the collector shoes

SUPERIOR
CARBON
BRICK
FOR
◀ Blast furnace linings
◀ Blast furnace run-out troughs
◀ Cupola linings
◀ Steel pickling tanks

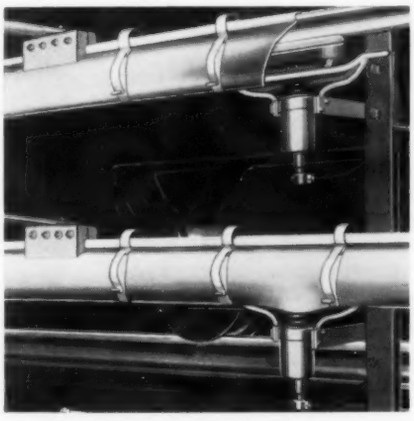
Standard sizes and shapes • Tested performances
Competent technical service • Superior chemical and metallurgical characteristics • Graphite brick also available.

May we give you a quotation?

ELECTRODE GLC® DIVISION
GREAT LAKES CARBON CORPORATION
18 EAST 48TH STREET, NEW YORK 17, N.Y. • OFFICES IN PRINCIPAL CITIES

can be mounted on a horizontal plane on minimum spacing of three in.

This is a copper-to-copper system which maintains total area of contact between conductor and col-



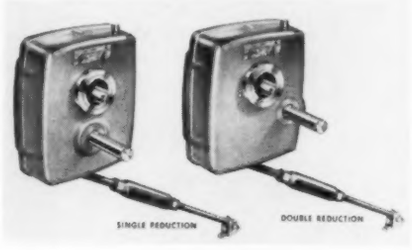
lector. This principle, together with the covering sheath, allows continuous operation despite the presence of dirt, grease or acid fumes. The system is self-de-icing on exterior installations subject to freezing rain or snow.

The system is for installations from 110 to 600 volts. Collectors are for from 70 to 1125 amperes. Five sizes of conductor bus are available, with electrical carrying capacities from 325 to 4500 amperes.

SPEED REDUCERS

△ Shaft mounted speed reducers with capacities from $\frac{1}{4}$ to 40 hp are now offered by Foote Bros. Gear and Machine Corp.

The reducers are equipped with adjustable torque arms, and may be supplied with or without an enclosed backstop. An interchangeable automatic overload release torque arm, which protects driven ma-



chines, motors and the reducer from excessive shock and overload by simultaneously loosening the drive belt and interrupting the electrical drive circuit, is available as optional equipment.

Offered in single and double reductions with output speeds from 10 to 420 rpm at 1750 rpm input using standard v-belt drives, the reducers are rated according to AGMA standards. The units are available in shaft sizes from 1 $\frac{7}{16}$-in. to 3 $\frac{7}{16}$-in.

Stock bushings, to adapt the hollow shaft of the reducer to the drive shaft of the equipment, are furnished in standard sizes. Locking collars at each end of the hollow shaft maintain the reducer in correct position, yet allow simple assembly of the unit.

Designed for quick, easy installation on the driven shaft, the reducers are compact and strongly built units. The tough, cast housing is designed with all ribbing on the inside, to provide a clean, streamlined exterior surface. Greater rigidity and strength have been provided at all critical stress points of the housing without adding to overall size and weight, by eliminating nonfunctional weight and mass.

CRANE CONTROL

△ A new d-c magnetic crane control for hoist, bridge and trolley motions on cab or floor-operated cranes has

for intense concentration of heat...

The BLOOM HTR BURNER

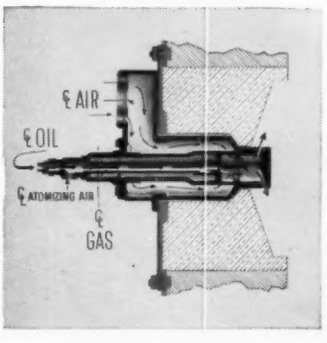
The Bloom HTR Burner provides identical operation on either gas or oil.

This burner enables the engineer to design a heat pattern with excellent results, because it has the unique characteristic of providing localized high heat release with low forward velocity. The burner can be located to fire directly at the material without flame impingement. Roof firing is easily accomplished and provides uniform hearth temperature.

This burner has been very successful in its application to tube upset furnaces; continuous strip annealing, coating, and pre-heating lines; high speed billet heating furnaces; and batch-type forge furnaces.

The Bloom High Thermal Release Burner with its sturdy construction is ideal for applications requiring speed and precision heating.

PATENT PENDING



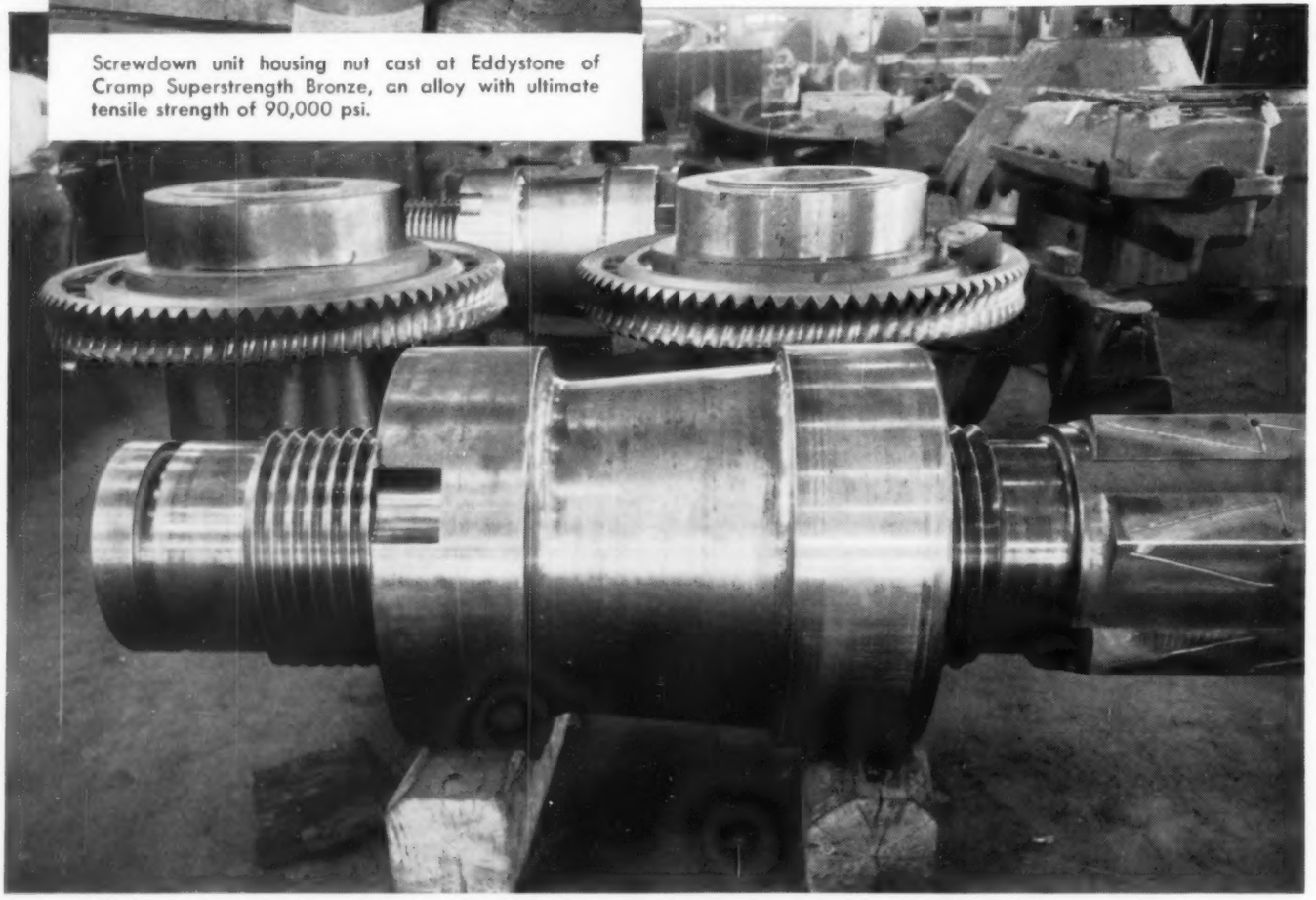
BLOOM ENGINEERING CO., INC.
837 W. North Avenue Pittsburgh 33, Pa.

Whether you need the complete finish-machined unit or simply rough castings or forgings, look to B-L-H

Screwdown unit housing nut cast at Eddystone of Cramp Superstrength Bronze, an alloy with ultimate tensile strength of 90,000 psi.

Baldwin's facilities are vast, its output varied. In some cases you may want only the rough castings or forgings. In others you may want the complete finish-machined unit. In any event you'll find that whatever your particular job demands, Baldwin can meet your needs . . . and often increase the service life of wearing parts by proper metal application.

Baldwin offers you fully staffed engineering and metallurgical departments and the most modern of chemical and physics laboratories. Equipment includes spectroscope, electron microscope, and X-ray machines, for both research and quality control. Machine tools run from small lathes to 42-ft. boring mills. These facilities, together with the skills of our experienced people, can help you. Write today for our illustrated Foundry Bulletin 6002.



Complete finish-machined screwdown unit which B-L-H's Eddystone Division supplied for a 38 x 59 x 110 4-high universal hot aluminum mill.

BALDWIN · LIMA · HAMILTON

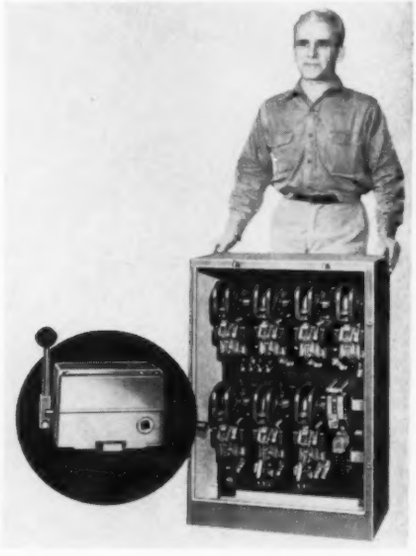
Eddystone Division

Philadelphia 42, Pa.

Hydraulic turbines • Weldments • Dump cars • Nonferrous castings • Special machinery • Bending rolls • Machine tools

been announced by EC&M Division of Square D Co. Designed to give full magnetic control at a cost comparable to manual control, the Type PT crane control can be used on any d-c crane application up to 55 hp, 230 volts.

Providing 3-point speed control in either direction, the PT crane con-



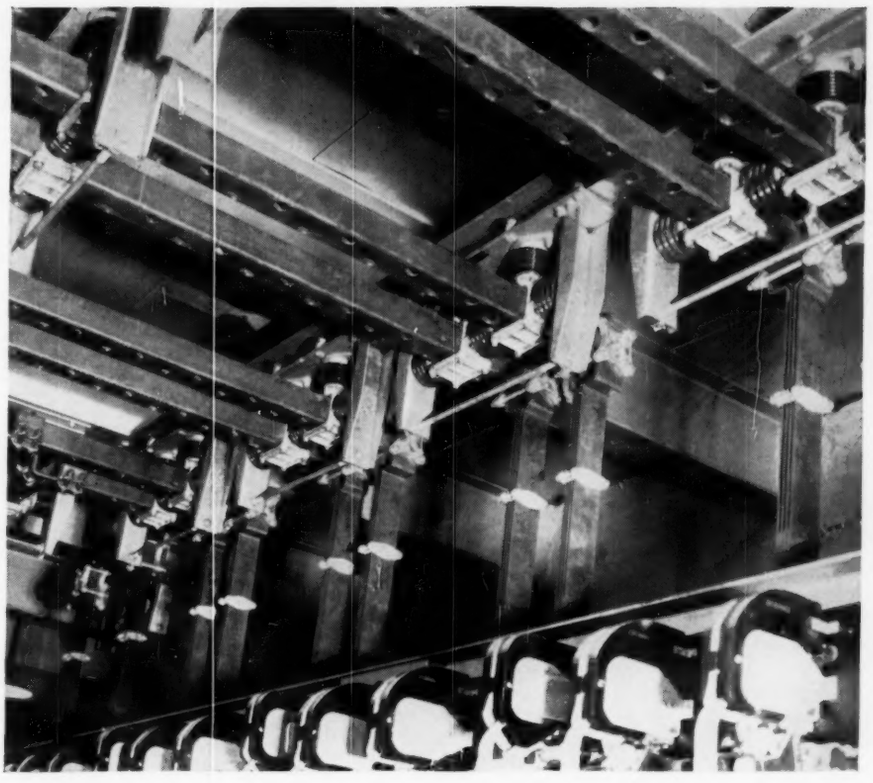
trol reduces motor wear through automatic acceleration. Acceleration relays are adjustable from 0.2 second up to 3 minutes per stop.

The controller is built to fit easily in crane cabs, on crane walkways, or wherever space is limited, and is front-connected to permit wall mounting. The master switch (see inset) can be ganged with other masters, or mounted directly on top of the completely enclosed controller. A separate panel for protection of 1 to 4 motors is available.

POWER UNIT

△ The availability of a 400 cycle mobile ground power unit has been announced by the Louis Allis Co.

The unit converts commercial 60 cycle power to a precise 400 cycle output by means of a synchronous



AVOID COSTLY DOWN TIME

with DELTA-STAR reinforced BUS STRUCTURES

When properly designed, bus structures can be relied on to withstand severe short circuits without damage. Delta-Star reinforced bus structures are engineered to withstand the maximum forces that may be encountered, consistent with the capacity of your system. Extra strength is built in by using heavy reinforced construction with high-grade wet-process porcelain placed in compression, taking full advantage of the porcelain's greatest strength.

Delta-Star engineers will be glad to work out your bus problems and develop a layout to suit your specific requirements.

OTHER DELTA-STAR PRODUCTS
Used in Mills and Industrial Plants

- Crane Rail Supports
- Disconnecting Switches
- Terminators (Potheads)
- Plugs and Receptacles
- LEC-TROL-FEED
- Spool Insulator Cable Supports
- Water-Cooled Conductors and Fittings
- Interrupter Switches
- Power Connectors

For complete information, see your Delta-Star representative, or write Delta-Star Electric Division, H. K. Porter Company, Inc., 2437 Fulton St., Chicago 12, Illinois. District offices in principal cities.

H. K. PORTER COMPANY, INC.
DELTA-STAR ELECTRIC DIVISION

induction drive motor and an alternator. This output is of an especially low harmonic content.

Magnetic amplifiers provide voltage regulation of plus or minus 1 per cent, with loads from 0 to 150 per cent of the alternator rating. At 200 per cent load, voltage will not dip below 180 volts from 208 volt setting. Magnetic amplifier excitation provides a fast response so that from no-load to full-load the output voltage recovers to within 98 percent of voltage within 0.15 second.

The drive motor used in the unit maintains an exact 400 cycles regardless of changes in load or line voltage. This motor accelerates as an induction motor and runs at synchronous speed without permanent magnets or d-c excitation involving collector rings and brushes, wound rotating fields, etc.

The unit is built in ratings of 50, 60, 75, 90, 100 and 120 kva.

COVER ASSEMBLY

△ A new high voltage bushing and terminal assembly is now being furnished by Wagner Electric Corp., on their single and three phase distribution transformers 167 kva and below, 5001 through 16,500 volts.

The phenolic insulating cover providing bird and squirrel protection is threaded to fit over the end of the high voltage terminal which holds it in place. A small slot in the side of the guard between the arrester electrode and the terminal electrode

provides the necessary gap for protected transformers. An insulated hand knob for tightening the terminal clamps makes it very easy to fasten the conductor in the terminal without a wrench. The terminal meets requirements of the EEI-NEMA specifications for vertical take off and conductor sizes.

The "T-Section" clamping member on the eye-nut of the terminal is designed with rounded contact surfaces that confine the line conductor in a small grooved space that effectively prevents the incoming high voltage line conductors from spreading or the terminal from rotating. Tin plated surfaces on the T-Section clamping eye nut and the terminal provide a connection of high mechanical strength and low electrical resistance for both aluminum and copper conductors.

When bare conductor is used, an accessory bakelite tube for additional protection is available for attachment to the top of the insulating cover.

In FRICTION SAWING it's ENTERPRISE that counts

ENTERPRISE Crop-End Saw, for ½ to 4½ in. OD pipe or tubing. Turret drive end.

For high speed cutting of hot or cold steel sections, production men agree that *friction sawing* has no equal.

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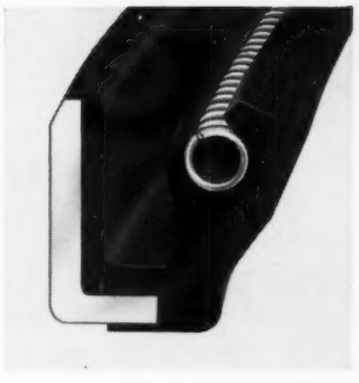

GARLOCK KLOZURE 2782—Positive oil seal protection for steel mill bearings. Garter spring holds Buna-N sealing element in contact with shaft. Precision formed case molded to sealing element protects seal from damage, and provides a press fit for proper installation. Available normal to high speed use on shafts to 48″ dia., temperatures to 250° F, and for applications involving low pressure differentials.

It's easier to find the KLOZURE Oil Seal for your job because Garlock has one of the largest stocks available. Moreover, for any sealing problem, you can choose from the Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seals. The only complete line. Call your Garlock representative or write for KLOZURE Catalog 20.

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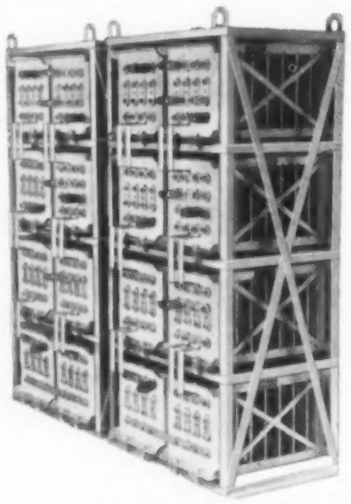

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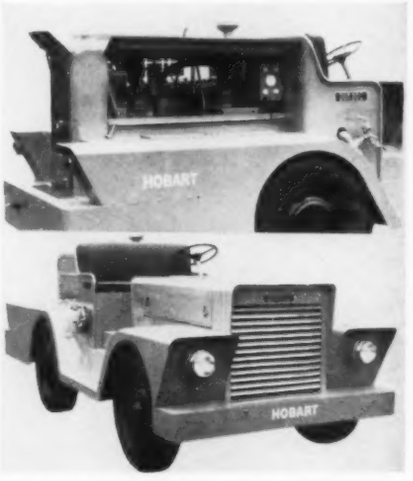
WELDER-COMPRESSOR

△ A new self-propelled unit for operations requiring both arc welding current and compressed air has been developed by Hobart Brothers Co.

Mounted on the rear is a 125 cu ft rotary type compressor driven by a

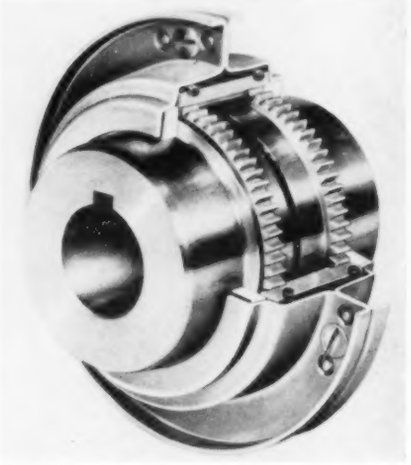


4-cylinder gasoline engine. The compressor is completely self contained with the exception that it draws its gasoline from a common fuel tank.

The welder is a 600 ampere d-c unit driven by a Chrysler V-8 engine. This same engine drives the vehicle through a special axle built by Hobart and through a transmission and torque converter. The unit is also equipped with hydraulic power steering.

COUPLING

△ Link-Belt Co. has announced a new low cost geared flexible coupling for shaft diameters up to 1⅞ in. Called the type MC, it is designed

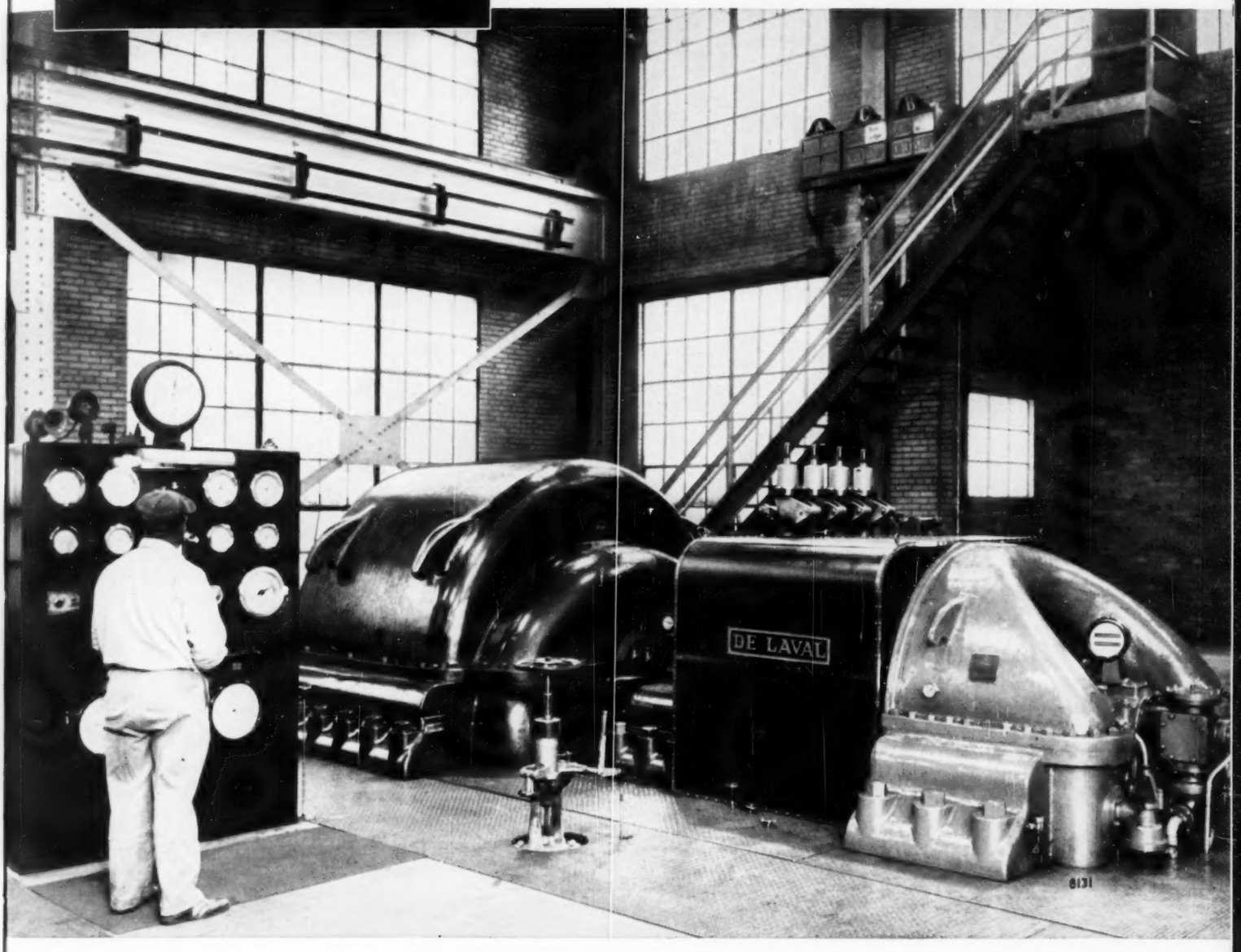


especially for use as a motor coupling —for transmitting electric motor power to pumps, generators, speed reducers, etc.

(*Please turn to page 226*)

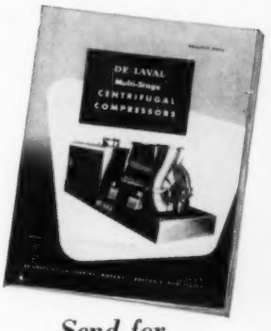
DE LAVAL
BLAST FURNACE BLOWERS

give 20 years of service at Great Lakes Steel Corp.



Shown is one of two De Laval centrifugal blast furnace blowers at the Ecorse, Michigan, plant of the Great Lakes Steel Corporation, Division of National Steel Corporation. This 85,000 cfm unit was installed twenty years ago; another 75,000 cfm unit went on the line a year earlier. Both have given dependable round-the-clock service ever since. These turbine-driven blowers are hooked up to a multi-head which enables either one to be used in conjunction with any of the three blast furnaces.

De Laval centrifugal blowers are built in single and multi-stage types to supply air in volumes up to 150,000 cfm for all classes of service in steel, gas and coke plants. The wealth of application experience acquired by De Laval over the years assures a correct and economical solution to your blower problem.



Send for Bulletin 0504

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DE LAVAL STEAM TURBINE COMPANY
870 Nottingham Way, Trenton 2, New Jersey

DL-361

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a statement by ***Julian B. Baird,*** *Under Secretary of the Treasury*

"America's great productivity has been made possible by the willingness of Americans to save a part of their incomes for investment in productive enterprises. The Payroll Savings Plan of the Savings Bond Program implants and helps to sustain the habit of regular savings, and this benefits our whole economy as well as each individual saver.

"We need savings as a continued affirmation of our way of life. The right to build up personal savings and to choose individually our savings objectives is one of our cherished freedoms.

"I am convinced that every bit of effort we put into Savings Bond promotion as part of a broad thrift plan will be richly rewarded in the contribution we shall be making to the strength and security of our country in this critical period."

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S. L. JAMESON — CHICAGO 2, ILLINOIS

PRODUCTS

Equipment News

(*Continued from page 222*)

Basic principles of operation are like those of a conventional geared coupling, i.e., externally geared hubs are mounted on the shafts and joined flexibly by an internally geared sleeve. Power transmitting parts are steel and fully machined.

The coupling sleeve is of one-piece design, and the coupling is enclosed in a two-piece metal cover, which is sealed to prevent loss of lubricant or entry of contaminants.

A special feature of the coupling centers on the use of spiral cam-locking fasteners which join the cover flanges. These fasteners are permanently assembled as part of the cover halves (there are no loose bolts and nuts) and require only a quarter turn for fastening or detaching.

Book Reviews

Best's **"Safety-Maintenance Directory,"** 1958–59 edition, prepared with the help of the nation's leading safety experts is now ready for immediate delivery. Six new sections appear for the first time. Over 2600 safety and maintenance products, devices and equipment are fully described and frequently illustrated, together with the names and addresses of 2500 manufacturers. This seventh bi-annual edition contains 642 illustrated pages, many in color, covering all recognized safety, first aid, sanitation, hygiene and fire protection products and equipment for all industry, giving, in most cases, a complete description of the product or device, including its use and the hazard it overcomes.

Book is available from Alfred M. Best Co., Inc., 75 Fulton Street, New York 38, N. Y. Single copies are priced at $7.50 with reductions on quantity orders.

"Zone Melting," by William G. Pfann has recently been published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. The book contains 236 pages, 9 × 6 in., is cloth bound and sells for $7.50. This book includes all the information necessary to plan a zone melting process, or to decide whether such a process is feasible. Both theory and practice are covered as well as yet unexploited potentialities of crystallization.

Featured also are comprehensive descriptions of how to build and operate zone refiners; a complete set of computed zone-refining curves showing impurity concentrations throughout an ingot as a function of the number of passes; a stimulating discussion of the largely unexploited continuous multistage techniques; and an extensive coverage of solidification methods for growing and controlling properties of semi-conducting crystals. The book is amply illustrated with photographs, graphs, charts, etc.

You can't shut out CANCER this way

FEAR AND DELAY are the two most potent allies of cancer. Too many Americans *needlessly* lose their lives to cancer . . . because they put off going to their doctors.

Many cancers are curable if treated *in time*. Even 15 years ago, medical science was saving 1 out of 4 cancer patients. Today, it's saving 1 in 3. The odds would be even better if people would have a health checkup annually and be alert to cancer's seven danger signals:

1. Unusual bleeding or discharge. 2. A lump or thickening in the breast or elsewhere. 3. A sore that does not heal. 4. Change in bowel or bladder habits. 5. Hoarseness or cough. 6. Indigestion or difficulty in swallowing. 7. Change in a wart or mole.

If your signal lasts longer than two weeks, go to your doctor to learn if it means cancer.

Having a health checkup every year is the smart thing to do—a checkup is your best insurance against cancer.

And it's equally smart to send your check to help in the continuing fight against this merciless killer.

Send your check to "Cancer" in care of your local post office.

AMERICAN CANCER SOCIETY

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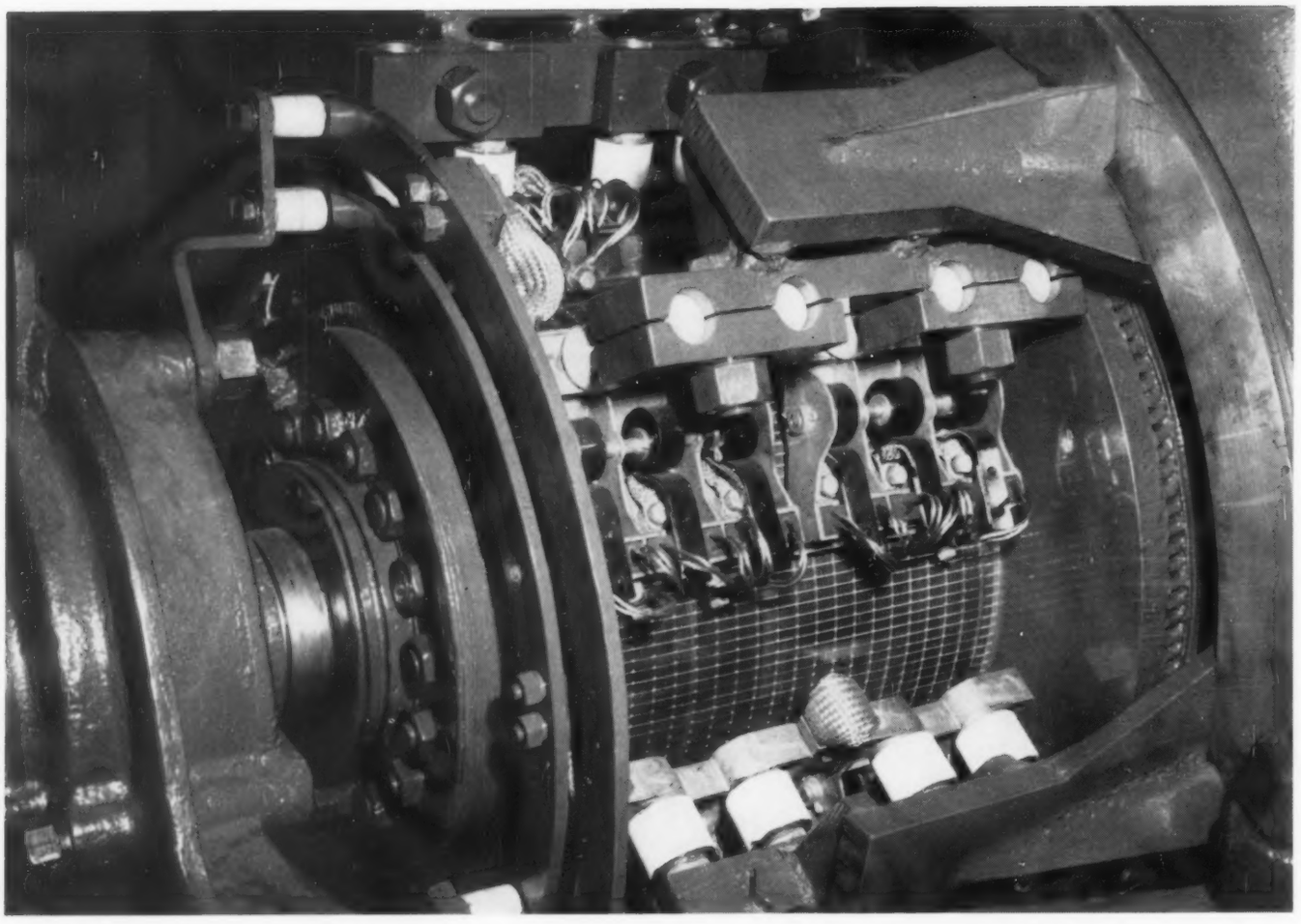


NATIONAL 'Improvement' Saved This Motor from the Scrap Heap

The motor shown above is one of three which powered bridge cranes on an ore unloading dock. After years of operation it was obvious that these motors had reached the point where complete rebuilding would be required to insure continued service.

The motor manufacturer considered the design obsolete and replacement parts were not available. But to replace the motors would have been extremely expensive. Not only would new motors have been required, but the existing crane structure would have had to be modified to accommodate them.

National undertook not merely to repair the motors but to redesign and modernize them. Work done included:

1. design and manufacture of new commutators
2. design and winding of new heavy duty fields
3. rewinding of the armatures
4. design and construction of more rugged brush holders and brush rigging.

As a result of National "repair and improvement", the motors were made more efficient in their performance and less costly to operate and maintain. The peak current demand of the redesigned units is on the order of 6000 amperes as compared to 8000 ampere peaks before rebuilding. And practically all of the parts now required for maintenance are standard stock items.

This case is typical of National repair service. Improvement, not merely repair, is always the objective. For details on how National redesign ingenuity can help *you* solve your tough electrical maintenance problems, just call your nearby National field engineer or drop us a line.

NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A.

TRADE MARK

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—
REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

Farval serves 1133 mill and crane bearings in Atlantic Steel's new bar and rod mill

FARVAL—
Studies in Centralized Lubrication
No. 205

KEYS TO ADEQUATE LUBRICATION—

Inset above shows Farval automatic pumping station No. 3, serving 240 points on 15 horizontal mills, edging mill, furnace switch and pullout, all designed and manufactured by Morgan Construction Company. Above you see *Farvalized* overhead crane and runout tables in the Atlantic Steel Co. mill room.

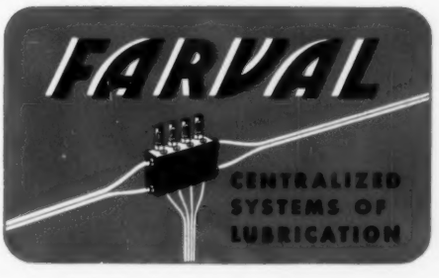
● Last word for modern machines and manufacturing practice, this Atlanta steel company also employs the most modern method of lubrication—Farval Centralized Lubrication. Twenty-four Farval systems keep mills and cranes running smoothly, serving a total of 1133 bearings.

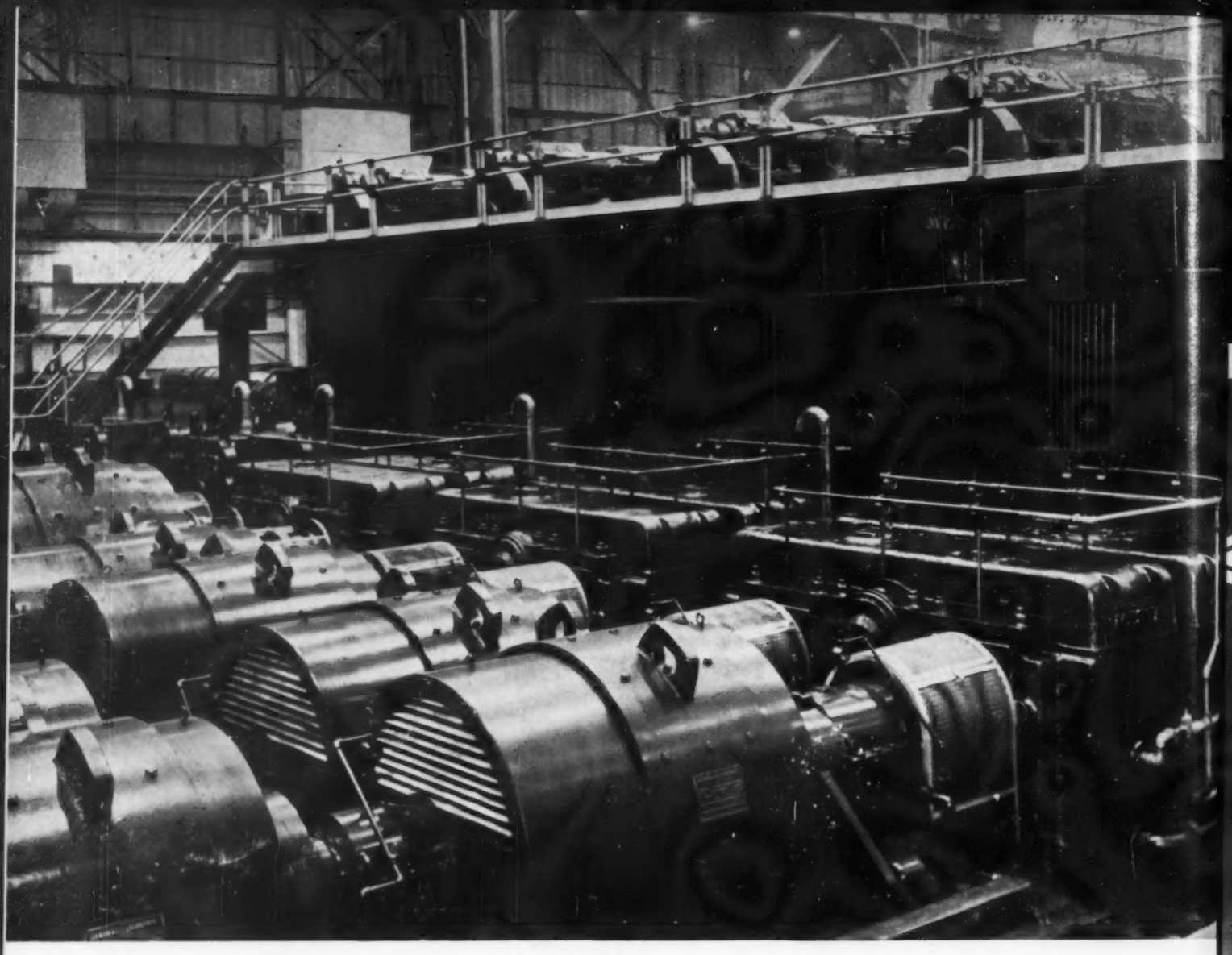
You'll generally find Farval in evidence wherever steel is made or worked. Literally thousands of systems, automatic and manually operated, protect millions of bearings in the metals industries—some of them still efficiently on the job after 25 to 30 years of service.

Farval is the original Dualine system of centralized lubrication that delivers measured amounts of oil or grease under pressure to every bearing as often as desired. No bearing is ever missed.

Write for newly revised Bulletin 26-S, which tells the whole Farval story. The Farval Corporation, 3278 E. 80th St., Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing.
In Canada: Peacock Brothers Limited.





Additives in Texaco Meropa give heavy duty gears "Boundary Lubrication" for dependability under pressure

To fully protect your reduction gears, use the lubricant that *keeps on lubricating* even under extreme shock and continued heavy loads—Texaco Meropa Lubricant.

In addition to its extreme pressure properties which cushion the gear teeth, Texaco Meropa Lubricant contains special *polar* additives that cling to the metal and prevent the lubricating film from being squeezed out—thus providing the "boundary lubrication" so vital to the long life of heavy duty gears operating under heavy pressures.

The result is increased gear life, minimum wear, and reduced maintenance costs when you use Texaco Meropa Lubricant.

The full line of Texaco Meropa Lubricants exceeds all requirements of main drive units and other steel mill machinery. Your highly qualified Texaco Lubrication Engineer will be glad to suggest the right one for your operating conditions. Just call the nearest of the more than 2,000 Texaco Distributing Plants in the 48 States, or write The Texas Company, 135 East 42nd Street, New York 17, N. Y.

LUBRICATION IS A MAJOR FACTOR IN COST CONTROL

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